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TEXTILE SERIES REPORT
NO. 126

TECHNIQUES FOR SALVAGE ANALYSIS OF CLOTHING, FOOTWEAR & TEXTILE EQUIPAGE

QUARTERMASTER RESEARCH & ENGINEERING CENTER
CLOTHING & ORGANIC MATERIALS DIVISION

JULY 1963 NATICK, MASSACHUSETTS

AD- Division 14:4 Accession No.

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S. J. Kennedy
Edward B. Frederick
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Louis I. Weiner

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FOREWORD

The study of wear, as a means of understanding the character and mechanism of ultimate failure of textile items, has always concerned textile technologists, home economists, clothing specialists, garment manufacturers, some retail distribution organizations and many consumers.

This report summarizes the salvage techniques developed and used by the U. S. Army textile and clothing research and development laboratories and the associated Field Evaluation Agency at Fort Lee, Virginia. These studies were begun during World War II when this work was directed by the Research and Development Branch of the Office of The Quartermaster General, Washington, D. C. After the removal of these activities from Washington to the Quartermaster Research and Engineering Center at Natick, these studies were continued.

The value analysis and engineering aspects of these studies will be recognized as a major objective of the Army's textile and clothing laboratories. Such salvage studies give an opportunity to reduce production costs of these items by extending their useful service life and by eliminating points of weakness which lead to failure in use.

Many millions of dollars have been saved as a result of the salvage studies which have been conducted by these laboratories and by the seam engineering and fabric development programs initiated as a result of the data obtained.

Industry has cooperated most effectively in programs based upon results of such studies, and in the redesign of many items and the revision of specifications to correct obvious points of weakness.

The consumer has also benefited from the dissemination throughout industry of the information on the use of such studies to correct structural weaknesses in textile items. Techniques of the Army Natick Laboratories in strengthening garment construction have been based on seam engineering practices which have come to be widely adopted in industry, and the civilian clothing industry has used many military-developed fabrics. This information has been made available to the public in the many technical reports on Quartermaster research and development in textiles released through the Office of Technical Services, U. S. Department of Commerce.

Of special interest to those concerned with protecting the consumer is the information in this report on techniques for sorting and analyzing failed garments. This report may also be of interest to home economists

who are concerned with the protection of the consumer through dissemination of knowledge on how a garment should properly be constructed in order to provide balanced serviceability of all its components and its construction methods.

S. J. KENNEDY
Director
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Approved:

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Scientific Director

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Brigadier General, USA
Commanding

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ABSTRACT

This report summarizes techniques developed by Army technologists for making salvage studies of textile items, equipage and footwear. Reasons for discard of clothing are discussed, together with clothing wear characteristics. Salvage items are requisitioned from basic training stations, overseas commands or areas of active combat. An original group of 500 items are required for a salvage study and they must be properly segregated, sorted and marked before forwarding. At the examining center Army technologists make a further random selection, using a sample minimum of from 25 to 50 for the study. They systematically examine each item, identify and classify the failure, then record on the check list the location and specific ranking (minor, major, critical). Any one of three methods of analyzing the results may be used, but it is recommended that more than one method be used. Included in the appendixes is part of a sample report of salvage analysis and a report on the analysis of 5,000 boots worn in Korea.

TECHNIQUES FOR SALVAGE ANALYSIS OF
CLOTHING, FOOTWEAR, AND TEXTILE EQUIPAGE

PART I. INTRODUCTION

1. Purpose and scope

Clothing, footwear, handwear, and equipment made from textiles constitute a unique class of items of military supply. They stand intermediate between supplies which are strictly consumable and heavy equipment items which have a relatively long life expectancy assuming normal maintenance and their not being destroyed during action.

Clothing and equipage items have an indeterminate service life that is usually relatively short but may under some circumstances be relatively long. They may be subjected to extreme strain only a few hours after being put on, or they may last for the duration of a campaign or live out their required service life of 9 months. However, they should be rugged enough to withstand conditions of sudden severe strain in the critical environment of the battlefield, and to assure protection against the environment and enemy-imposed hazards at any time they are being worn, at least until there is an opportunity to turn them in at a clothing exchange-bath unit[1], where fresh items can be issued and repairs can be made. This ruggedness is particularly necessary in clothing designed to provide protection against chemical warfare agents, since holes or tears cannot be tolerated in garments worn before or during attacks involving such agents. In view of the necessary interactions among the various components of clothing and equipage, it becomes necessary to think in terms of "total serviceability" in addition to the serviceability of the individual subassemblies and materials. If failure occurs in one critical component it may be of little value to the soldier that the other components of his assembly are functioning satisfactorily. Thus it is not unreasonable to think of having "balanced serviceability" in clothing design so that all of the components if they must fail will fail simultaneously as in the Deacon's one-horse shay.

Balanced serviceability should be designed into the following: the base fabric; the closures (buttons, snaps or side fasteners); and the sewing thread and seams by which the various parts are held together.

In addition, both the concept of fit in the original design and the actual fit of the items as issued and worn by the individual soldier must be such that undue strain will not fall on any particular component or area. This is important to eliminate both restriction on the wearer and premature failure of the item due to strain. Natural weak points where the cloth is sewed on a curve or at points of flexure or strain should be compensated for in the cut of the garment or else reinforced.

The study of items that have failed in use is a necessary part of value analysis and also of research and development, in order to determine the kind, character, and location of failures which occur in normal use, and how to prevent them or compensate for them.

The first step in such studies should be to determine whether or not the end item had a "reasonably adequate service life" or whether there is evidence of premature failure. When failures are found that have apparently occurred before a reasonably adequate service life, then corrective measures in design, construction, or materials should be made to prevent their reoccurring in new items. Personnel at the U. S. Army Natick Laboratories have called this type of value analysis study "salvage analysis".

Studies conducted during World War II, during the Korean War, and in subsequent years have shown that salvage* analyses of clothing, footwear, and textile equipage can lead to substantial improvement in the serviceability of these products at little or no additional cost. This results in great savings to the United States Government. Continuing salvage analysis studies of clothing and articles of footwear, handwear, and equipage are accordingly needed both to check on the serviceability of materials and construction methods, and also to bring these items to that point of maximum serviceability per unit of cost that will result in a full dollar's value for each dollar spent.

There are certain types of data on the performance of such items that serve a somewhat similar purpose as salvage analysis, but to a limited extent. These include the three sources discussed below. One source is the data obtained from engineering or service tests during the development of an item. Information on performance failures obtained during such tests can lead to corrective action in construction methods or selection of materials before the item is type classified. Another source of data is "unsatisfactory equipment" reports. These are by their nature inadequate for corrective action in clothing; so many failures are fortuitous (i.e., due to chance or accident) that it is rare for such reports to characterize the type or cause of failure. A third source of such information is the records kept in clothing repair shops. Such records list repairs actually made, but the records have been found to be of little value in leading to an accurate understanding of the nature of the failure and of how to overcome it.

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* According to AR 320-5, Dictionary of U. S. Army Terms, the word "salvage" used in connection with military items suggests that they have some value in excess of their material content, but that they are not usable as a unit without major repairs or alterations. "Scrap" refers to items which have no value other than their material content.

Experience with studies of performance failures of clothing, equipage and shoes has shown that systematic examination of salvaged items by technical experts is the only way to determine practical corrective action.

For this examination, suitable samples of failed items should be selected at points of collection, preliminary screening made to eliminate non-typical failures, and then careful analysis made by qualified technical personnel following properly developed procedures. For this analysis, examiners need to be furnished with specifically outlined charting materials and visual aids so that the data they collect will be significant and useful in determing what changes in specifications, construction or materials should be made.

This report outlines briefly the characteristics of wear in textile items, the proper selection of samples of worn items, and tested procedures for examining for failures, and tabulating and analyzing the results.

2. Reasons for wear-and-tear discard of clothing

Many different fabric properties may affect the wear characteristics of textile garments. Perhaps the most important is the fabric construction itself. A fabric that is tightly woven will have relatively high resistance to snagging or penetration by foreign objects; on the other hand, a loosely woven fabric is more susceptible to snagging. However, a loosely woven fabric possesses greater ability to deform under strain, thus maintaining a higher resistance to tearing, and under some conditions, because of its better drapeability, it may also resist abrasion better.

The type of fabric weave is also important in considering wear characteristics. Sateens and some twill fabrics possess directional wear effects. For example, a warp sateen will have high abrasion resistance in the warp direction on the back side; this is because the filling yarns must be worn through before wear begins to affect the warp yarns. However, in the filling direction on the back side, this same fabric would have lower wear resistance because the filling yarns, which in this orientation are the stress-bearing yarns, would be worn through first.

Fabric weight and the amount of twist in the yarns also affect wear resistance. A heavy fabric will usually have better wear resistance than an otherwise similar lightweight fabric, simply because there is more fabric to be worn away. Fabrics woven from low-twist yarns usually have a shorter wear life because these yarns will have less strength than higher-twist yarns and therefore are more susceptible to snagging and to abrasion of the individual fibers.

The introduction of the high-strength synthetic textile fibers has

made possible very greatly increased wear resistance of textile fabrics and articles made from them. When blends of cotton and nylon or polyester fibers are used, the fabric wear may be increased to several times that of all-cotton fabrics.

The finishes and treatments that are applied to the fabric will also alter the serviceability of textile materials, sometimes increasing their service life, and sometimes decreasing it. Some resin treatments will reduce fabric strength, simultaneously reducing the fabric's resistance to abrasion and tearing. On the other hand, finishes which contain lubricants may increase the resistance to abrasion.

Photochemical deterioration as a result of exposure to the ultraviolet rays in sunlight and chemical deterioration as a result of an excess of bleaching agents in the laundry will weaken textile fibers and reduce their ability to withstand the abrasion and other strains of normal service wear.

3. Discards not reflecting on serviceability

It should be recognized that clothing and equipage items are discarded for many reasons other than wear and tear. A local commander may demand their discard, regardless of cost, in order to maintain the appearance of his unit. The garment may have lost its coloring by improper laundering, by attempts of the individual soldier to get the "veteran look" by whitening a garment, or by the fraying of garment edges in the drier of the laundry.

Also, failures of a fortuitous nature may result in discard. This type of failure is generally found in fairly new items where the basic fabric shows only a minor amount of wear. These failures include burns, acid deterioration, and components ripped or torn loose (pockets, collars, and slide fasteners) large rips and tears, and irremovable stains (e.g., oil, grease, or paint).

Also, during seasonal changes of clothing or when troops are demobilized, items are turned in which, for one reason or another, may not be reissued; these will be found in salvage piles without any apparent reason for the discard. The quantity of such items varies from one unit to another, and their proportion of the total group may be large. In a recent salvage analysis of clothing items, approximately 60 percent of the group still had useful service life.

Many discarded items show indications of being altered. For instance, side seams of jackets or shirts may be taken in at the whim of the wearer in order to provide a tight fit at the waist. Such garments may show thread failures or fabric tears along the altered seams, caused partly by the use of improper or inferior thread, and partly by the strain of too snug a fit. In particular, back seams or armhole seams may have failed,

or buttonholes may be torn because of excessive strain imposed by such alterations. Also, fatigue trousers in which creases have been sewed will show high incidence of wear along the crease because of the hard edge formed by the stitching.

It is also evident to anyone who has looked at many samples of salvaged clothing that some items, particularly clothing, have been deliberately damaged in order to justify their discard.

The above-mentioned prematurely discarded items do not reflect the relative serviceability of military clothing to fair wear and tear. Therefore, these items should be segregated from the group when a salvage study is conducted and, if desired, analyzed separately.

PART II. SHIPPING ITEMS FOR SALVAGE STUDY: SOURCES AND INSTRUCTIONS

4. Sources of samples for military salvage studies

In planning a salvage analysis, consideration should first be given to the representative types of service wear. There are three general types of service from which samples may be collected: (1) basic training stations, where all the men in a unit have equivalent duty; (2) overseas commands in peacetime, where most of the troops are on duty assignments involving substantial wear; and (3) areas of actual combat, including such "cool war" activities as those of the British Commonwealth troops in Malaya. These three sources will be discussed below.

It may be difficult to take salvage samples from troops in basic training and to exclude samples from non-training general-service troops, but every effort should be made to segregate them. Proper selection of samples is complicated by the fact that peacetime clothing is personal rather than organizational equipment and is paid for out of the soldier's clothing allowance. Because of this difficulty it may be justifiable to make special studies in which the clothing for subsequent salvage is supplied by the analyzing agency, much as clothing for engineering design and engineering tests is supplied now. Such studies involve controls which may prove impractical on a continuing basis, yet the value of these studies should not be overlooked, and if an opportunity arises for carrying out such analyses, they should certainly be attempted.

The most practical source of clothing and equipage in salvage analysis during peacetime is probably from troops in overseas commands. This source is particularly valuable in showing the effects of a kind of field wear that may lead to the irrepairable failure of a single component in a garment when the garment itself would otherwise be serviceable. However, because of the distance of such overseas commands from points at which significant studies can be made, the analysts may not be able to assist in the original sorting, and consequently the representativeness of the groups may be open to question. This problem might be overcome by providing detailed instructions to those who will be selecting the groups of items to be analyzed.

Salvaged clothing from troops engaged in some type of active combat can be expected to give the most valuable information. This clothing is likely to have received heavy wear or strain; when it is damaged, it has to be replaced before the troops return to the combat area. Acquiring such items by issuing new ones should usually prove practical.

Salvage acquired from seasonal turn-ins (the exchange of cold-weather for hot-weather clothing, and vice versa) will have to be carefully screened before its use in a salvage study. However, deteriorated

garments or footwear may be thus obtained and should provide significant data.

It is important not to mix items salvaged from the three main service sources discussed above. Each group of items should be kept separate and should be clearly marked as to its origin. (It will be possible to average the results from all the sources later, if desired.) However, the "standard" of salvaged items from one source will usually not be the same as that from another source. These differences in standards could adversely affect the final analysis. Furthermore, a comparison of the "standards" from the different service sources should be helpful in understanding the character and probabilities of breakdown of the item in use.

5. <u>Selecting and shipping items for a salvage study</u>

There will usually be a limit to the demands that can be made on the military headquarters by personnel making a salvage study. Therefore, it is necessary to requisition the items to be given detailed analysis in the simplest possible terms. In this connection, three elements of separation may be considered: the lot, the group, and the sample, as defined below.

<u>Lot</u> - The lot represents the total population of garments of a given type, available in the classification area of the military headquarters.

<u>Group</u> - The group, requested by the technical personnel, will normally consist of a random selection from the lot to provide approximately 500 items which are to be shipped for evaluation. NOTE: the term "random" means that the probability of selecting any one item should be equivalent to the probability of selecting any other item. A smaller number than 500 may constitute the group if 500 items can not be obtained. However, experience has shown that, in order to provide a significant quantity (after sorting and discarding those that do not really belong in the sample as actually "failed in service wear"), a group of about 500 is needed to work with.

<u>Sample</u> - From the shipped group, the sample for direct evaluation will be selected, again randomly. The sample should comprise at the very least 25 items but preferably 50.

One time and labor-saving method of obtaining a "random selection" is to select a given number of items from the processing line every hour on the hour until a group of the desired size (500) is obtained. However, any method that leads to actual randomization would be satisfactory. Only by adhering to a valid random basis, however, can statistical validity be achieved.

For each group the following information, prepared as accurately as possible, is required concerning the items for shipment: (1) the kind of duty under which the items were used (e.g., predominently in basic training, in overseas service, etc.); (2) the approximate size of the lot from which the group was taken (for example, if the items were selected over a period of a week, the number of items of that type that were processed during the week); and (3) the number that were selected, during the period, for the group. (From this the ratio of the size of the group to the size of the lot can be computed.)

PART III. TECHNIQUES FOR EXAMINING FAILURES IN CLOTHING ITEMS

6. Final preparation for analysis

For the final sample selected to be analyzed the assumption is to be made that all the items can be considered to have experienced fair wear and tear and to be not economically repairable. If items of clothing had not already been laundered before they were shipped, they should be laundered before analysis is begun. This may be done immediately after receipt, if they are covered with battlefield grime.

7. Tabulation of failures

The quality of the examination of the samples randomly selected from the group is of extreme importance. It must be objective and not based on the arbitrary judgment of the examiner. The type of questionnaire, chart, or visual aids furnished the examiners must be sufficiently clear-cut to avoid bias in ratings, or sloughing off differences that may prove to be significant data. A set of rules is needed to which the examiner can firmly adhere. In this way, the objective of the study will be achieved with a large part of the analysis reduced to a more or less mechanical effort on the part of the examiner.

The examiner should check for failures in a systematic manner. A logical approach is to start at what is commonly regarded as the top of the item. In shirts, jackets, parkas, and coats, the collar would be the normal starting point; in trousers and similar apparel, the waistband would be the point. The front and back of the garment and the inside, as well as the outside, should be scrutinized carefully.

Each failure should be recorded, together with its location and rating, using a form such as that given in Appendix A. The failures should be rated as "Minor", "Major", or "Critical", as described below.

A "Minor" failure is one that is readily repairable without significant loss of service time; when it is repaired, the garment is restored to approximately first-class service.

"Major" failures are those that need extensive repair by a machine and for this repair the garment must be taken out of service temporarily; after repair, the garment will perform satisfactorily as at least "Combat Serviceable."

The third category, "Critical"*, should be divided into two sub-

* "Critical" refers here to being "Critical" with respect to the garment's continued use--not to the character of the garment's original intended use. It means that the item has reached the end of its useful life because of a "Critical" failure.

categories: (1) those failures that are susceptible to repair but, even after repair, may prevent the garment from performing satisfactorily from the standpoint of serviceability, functionability (if a protective garment), measurements (which might have been affected in alterations) or appearance; and (2) those failures that are not repairable under any consideration. Failures falling into sub-category (1) can be classified as "Critical 1"; those in sub-category (2) can be classified as "Critical 2".

The following symbols may be used to identify the severity of failures:

✓ - Minor
X - Major
C_1 - Critical 1
C_2 - Critical 2

Unless garments with the "C_1" type of failures would be needed for emergency use (as during World War II when such items were used to clothe prisoners of war), this classification would indicate that the item should be scrapped. All C_2 failures represent items that should be scrapped.

8. Analysis of failures

Several methods can be used to analyze the results of the examination. Each of these may be of value in a particular study, but in many studies more than one analysis should be made, as the analysis included in Appendix B illustrates. Care should be taken to analyze the failures accurately and to state and define the results clearly. An analysis which is confusing will greatly lower the value of the entire salvage study. These methods of analysis are described below.

Methods of Analysis

1) In one method, the proportion of the sample that contains particular kinds of defects or failures is computed, and then failures are related to their location. For example, in the evaluation of trousers, one might find that 50 percent of the holes occurred on the right knee; 30 percent on the left knee, etc.

2) In a second method of analysis, the extent of wear is broken down into degrees of failure. Degree of failure is a score assigned to holes, tears, frays and wear areas; the value of the degree of failure has been predetermined to reflect the extent to which the type of failure influences the serviceability of the item. For each type of failure, the degree of failure may be correlated with the amount of wear, the local conditions, and the type of duty under which the garments were worn.

3) In a third method, the total number of garments is divided into categories according to the type of failure noted. For example, 40 percent of the garments may contain holes only; 20 percent, tears only; 15 percent, both holes and tears; 10 percent, seam failures; and 15 percent, frays. It should be noted that 100 percent of the garments will thus be accounted for.

In addition, laboratory tests may be used to determine the amount of wear to which a garment has been subjected, by determining the amount of wear still left in certain critical areas. However, in using these tests the contract specifications have to be assumed to be the initial condition of the garment. For this reason, the value of tests of this type is somewhat limited, although they may provide useful criteria for estimating the service life when new. On the other hand, such laboratory tests as those for pH and fluidity may be useful in determining the cause of fabric damage.

Wear Scores - Several scoring systems have been devised to measure the degree of wear observed on garments. At the Field Evaluation Agency, Fort Lee, Virginia, where wear studies of this type were initiated early in World War II, the four types of wear (holes, tears, frays, and wear areas) are each given an arbitrary number, designated as "degree of failure". The length of tears and frays and the diameters of holes are measured in inches; the areas of wear are measured in square inches. To increasing class intervals for each type of failure, a degree from 1 to 6 inclusive is assigned. Point values for each degree and type of failure are arbitrarily assigned. The sum of the point values for a particular garment constitutes its "wear score".

The British have recently developed a somewhat different scoring system in which the sum of the length of tears and the square root of the total hole area are used as the measure of wear(2). Frays and wear areas are ignored in this system. Although this system is by far the simpler of the two, it does not solve the problem of weighting each category of wear.

9. Seam failures

It is generally recognized in the clothing trade that there are major and minor seams. The major seams are those that join the integral parts of the garments. In shirts, jackets, and coats the seams in this category are the back and side seams, the sleeve seams, the shoulder and armhole seams, and the collar and stand-joining seams. In trousers, the major seams are the inseams, outseams, seat seams, and waistband-joining seams. Failure in any major seam is generally critical to the function of the garment. In protective garments, the protection intended is seriously impaired by failure in a major seam. Also, these seams connect areas of garments in which the greatest tensions are developed

during wear; hence, many major seams are subject to high degrees of abrasion.

The minor seams are the "finishing" seams, which are used to make or join small parts, or for hems, binding, trimming, edge stitching, and the like. Failures in minor seams are usually not critical and will not usually seriously affect function or protection of the garment.

In a study of salvaged garments, seam failures should be weighted according to their relative importance in the function of the garment. Greater weight should be given to a small failure in a major joining seam than to a similar-sized or even a somewhat larger failure in a minor seam.

Attention, however, must also be given to the length of the seam failure. If an isolated 1-inch failure occurs in a major joining seam, this could not be considered critical or a valid reason for salvaging the garment. Even large failures in hems, bindings, top or edge stitching, and in other minor seams can be hand-repaired by the wearer or quickly machine-repaired by the laundry. If they are the only failures in the garment, it should have been repaired and not salvaged.

No matter how small the failure, its frequency within and among garments should be considered in determining its seriousness. The frequency pattern generally will indicate whether this failure is attributable to a wear pattern peculiar to a special use or whether it is attributable to faulty design or inadequate engineering of the seams.

Experience with salvaged items indicates that long seam failures, perhaps 6 to 10 inches in overall measurement, whether the failure be in the thread or in the fabric, are attributable to one or more of the following factors: (a) a chance occurrence in which some inordinately large force has been thrust upon the particular part of the garment, (b) a critical point reached in the service life of the item, (c) severe damage to the fabric during sewing; and (d) an under-engineered seam. The fortuitous failure is easily spotted by its low rate of occurrence.

If the thread has failed in raised stitching or in a felled seam, it must be determined whether stress or abrasion contributed to the failure. Inspection of the seam and the adjacent area of the fabric should readily reveal whether the failure has been due to heavy abrasion, poorly made seams, raw edges not properly caught, too-tight stitching (puckering), non-uniform stitching, or adjacent fabric failure. The number of stitches per inch adjacent to the failing thread and perhaps the size of the thread may be clues to failure: both the number of stitches per inch and the size of the thread could contribute to early failure if both were on the low side.

Fabric tearing along the line of stitching can be attributed to several factors. One, of course, is the damage done to the fabric yarns by the sewing machine needle when the garment was made. This condition would have been evidenced by fuzziness around the needle or by stitch penetration in the untorn area of the seam. Another cause of fabric tearing can be extreme curvature, so that stress may be concentrated on a small area of the fabric instead of being distributed uniformly and over a large area by means of gradual arcs. A third cause of fabric tearing can be a concentration of stitches at one specific point to cause a high amount of local yarn severance which would reduce the fabric strength in that area.

Of course, general stitching failure can be attributed to many outside influences. A protruding object can tear pockets from a garment or pull apart buttonholes when the object becomes caught in the fabric.

Often seams and stitchings fail for none of the reasons discussed above. Studies* concerned with improving the durability of pockets in the Coat, Man's, Field, showed that stress flows along seams and often causes failures in areas some distance from the impacted or stressed area. Therefore, the condition of the entire garment must be studied for the probable cause of the failure.

10. <u>Fabric failures</u>

There are four primary types of fabric failure: (1) wear areas, (2) holes, (3) frays, and (4) tears.

<u>Wear areas</u> are produced by surface abrasion in which individual fibers or groups of fibers are snagged, torn, or cut, but yarn structure itself remains intact. To the eye such wear areas appear as roughening or change of coloration of fabric surface. These abraded areas are found at points of heavy wear, such as in the knees of trousers. However, the location of wear areas will vary, depending on the fit of the clothing and the assigned duties and the personal habits of the individual wearing the clothing. The location of the wear area, the size of the wear area, and the amount of wear should all be noted in the final analysis of the garment.

A hole in a fabric has been defined as "a gap where yarns are

* 16 pounds of lead were placed in the lower pocket of coats and the coats were dropped 17 feet on the end of a nylon webbing, which stopped the drop sharply. The weights, fighting to continue their downward progress, caused a severe impact loading of the entire coat, and the stitching broke in the side seams as well as in the shoulder area. Of course, damage occurred in the pocket areas as well.

missing in one or both directions." Fabric holes are normally found in areas of heavy wear, but their location depends (as do wear areas) on the individual and the condition under which the garments were worn. The location and size of the area of missing fabric are important to note, as well as the number of holes in the worn area.

Linear wear along the facings and edges of a garment is known as fray. This type of failure is caused by abrasion that causes individual yarns to be ruptured. Frays normally occur on pockets, cuffs, collars, and flys, but they may also be found on other creases or edges of the garment. The length and location of each fray should be noted.

Fabric tears may be of the type found in wear areas, or they may be accidental and found in other areas of the garment. A tear in a wear area is a break, snag, or burst caused by strains and the general weakening of the fabric as a result of wear. An accidental tear is a break, snag, or burst caused by abnormal strains or snagging in the fabric. The direction of tears is dependent on not only the direction of the forces causing the failure, but also on the fabric geometry and yarn strength. In addition to the length and location of the tear, the direction of the tear should be noted so that the fabric may be better evaluated.

In Appendix C is given a list of the failures of seams and fabrics which should normally be identified in salvage analysis of clothing.

PART IV. ANALYZING FAILURES OF TEXTILE EQUIPAGE

11. Equipage items and their construction

Items of textile equipage, like the clothing discussed in the previous paragraphs, are made to serve specific purposes and in turn must be properly designed to fulfill these needs. In order to provide the combat soldier with more efficient equipment, these items also must be studied in detail during a salvage analysis.

Items in this category include load-carrying equipment (such as field packs), canteen covers, intrenching shovel covers, ammunition belts and pistol belts, and protective items such as ponchos and sleeping bags.

The "duck" for equipage items ranges in weight from 9.85 to 27.12 ounces, depending on the type used. Two types of ducks are used: numbered and flat. Numbered ducks have ply yarns in both the warp and filling directions. Flat ducks (rarely used in equipage) are woven with two single ends weaving as one, with either single or ply filling. All ducks are woven with a plain weave and are usually hard, firm cloths which can withstand abrasion. Ducks now used in equipage are all treated to impart water repellency and mildew resistance.

Webbing is very important when used as straps for supporting the load-carrying items such as field packs and for pistol and ammunition belts. Webbing contains plied yarns in both warp and filling directions and also has binder and/or stuffer warp. Binder warp are the yarns which tie a double fabric together. Stuffer warp is used for firmness and low extensibility or stretch. Webbing, like duck, is treated for water repellency and mildew resistance.

The seams of equipage items are especially important. With exceptionally heavy fabric, the thread must be strong enough to avoid breaking, but should not become a focal point for tears to begin. Metal hardware and grommets must be suitably attached to avoid being pulled out during use.

12. Special nature of failures

Mildew damage may be a problem with equipage items if they have been used in tropical areas. Normally duck and webbing used in equipage items are treated for mildew resistance. Thread used in equipage items should also be treated for mildew resistance unless synthetic fiber threads have been used. Polyester thread has recently been adopted in such items by the U. S. Army in preference to nylon thread, because of its superior resistance to ultraviolet deterioration.

Pulling out of grommets and metal hardware is another critical

problem in equipage items. Under some conditions it may be accentuated by catalytic reactions between the metal and the fabric finish.

Because their use involves outdoor exposure, equipage items may show serious deterioration from exposure to sunlight for extended periods of time. This damage may be evident in loss of strength in the fabric or seam and also loss of camouflage effectiveness. There is also the problem of the "veteran look" where rookies bleach and scrub their equipment to make it look like that of "veterans". In the process, they may actually damage the fabric, as well as destroy its camouflage properties.

Mechanical strains may be a problem on some items of equipage, particularly some parts of the load-carrying system. Damage may be caused by cutting tools (carried in the pack) or by heavy loads. Projecting flaps, pockets, and hardware become focal points for tears to start. Also, seam failures become more important because large stresses applied to a local seam can result in its failure.

Many of the problems described above apply to sleeping bags. The primary causes of salvage of sleeping bags are either tears in the fabric or zippers that have been pulled loose. Unlike the other items considered sleeping bags contain a filler, usually feathers or down, which may rot or give off an offensive odor if allowed to remain wet or damp for an extended period of time.

13. Analysis procedures

Textile equipage items may all have the same types of analysis that were discussed for clothing. In order to provide valid data, the item used in the salvage study of equipage must be from a random sample. The actual observation and charting of the failures should be the same as for clothing items. However, as the items serve purposes somewhat different from clothing, their evaluation should be altered to fit the significant use or construction aspects that apply.

Appendix D contains data from a previous salvage study, including the analyses that were made on three equipage items. These will suggest methods of approach to equipage analysis.

PART V. ANALYZING FAILURES OF FOOTWEAR

14. Stresses and forces leading to failure

Probably no item worn by the combat soldier presents more complexities in structure and use of materials than boots and shoes. As many as 78 different structural elements and 20 different basic materials are used in the tropical combat boot. In addition, the mechanical and environmental stresses to which boots are subjected lead to rapid failure in use. The pressures to which a boot is subjected can be as high as 850 psi when the heel first makes contact, but for most of the step it is about 20 psi. Tangential forces which tend to produce shear forces leading to separation of components and stress upon thread, amount to 50 lb[3]. During every moment of use the sole of the shoe is subjected to constant abrasion with the ground, the inner components to a constant flow of chemically active perspiration from the foot, the outer components often to heavy rainfall, mud, dust and every conceivable type of organic and inorganic material from the physical surroundings. Because of constant contact with the ground and the high-humidity environment provided by the foot and outside moisture, the boot becomes an ideal medium for the growth of mildew and bacteria which are well adapted to survive and destroy the organic components of the boot. Catalytic action between metal and the moist leather and fabric also leads to rapid failure and degradation.

15. Classification of failures

Salvage analysis of boots and shoes can be considered as either area failures or mechanistic failures. Usually there is a significant interaction between the two, since certain parts of the shoe are subjected to specific stresses (mechanical or chemical) which make the area studies of value. For example, shoes and boots may be classified in terms of failures such as outsole, insole, heel fastening, sole fastening, quarter closing, and upper failures. Each of these area failures may then in turn be further broken down, for a given area, into bond failures, stitching failures, and nail failures.

Looking at the boots and shoes in terms of the mechanisms of failure, such factors as abrasion, mildew damage, sunlight deterioration, and water or perspiration damage may be considered as causal factors and the influence of each of these factors on the various components and materials of the shoes should be tabulated.

In October 1951 a comprehensive analysis was made of 5,000 pairs of salvaged boots worn in Korea. Results of this analysis revealed many focal points of failure which led to corrective specification action. This study represents an excellent prototype for salvage analysis of this nature and is included in its entirety in Appendix E.

CONCLUSIONS

Systematic studies of salvaged items of clothing and personal equipment as suggested in this report are a means of providing information which cannot be obtained from other sources. Consequently, a systematic value analysis program for improving serviceability of clothing and equipage must be based on such analysis of salvaged items. Studies on serviceability must be a continuing objective of Army research on clothing and textiles to obtain items of improved design and construction. Development of materials of improved serviceability will simplify the logistics of supply and maintenance, and thus reduce military costs in time of war and cost to the taxpayer under all circumstances. In addition, such materials will provide more satisfactory substrates to which the special chemical finishes required for Thermal CBR protection must be applied to produce combined protection clothing and equipment.

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APPENDIX A

SUGGESTED SALVAGE ANALYSIS CHECK LIST FOR
ITEM: SHIRT, MAN'S, COTTON, OLIVE GREEN 107
(Specification No. MIL-S-3001D)

	Fabric Failure					Seam Failure	
Location	Holes	Tears	Frays	Wear Areas	Fading	Thread	Tears
COLLAR							
Breakline							
Edges							
Joining							
SHOULDERS							
Right							
Left							
ARMHOLES							
Right							
Left							
SLEEVES							
Right							
Top							
Bottom							
Left							
Top							
Bottom							
Hem							
FRONTS							
Right							
Left							
Pockets							
Body							
Flaps							
Lapels							
Right							
Left							
Buttonholes							
Buttons							
Bartacks							
BACK							
SIDE SEAMS							
Right							
Left							
BOTTOM							
Hem							

APPENDIX A (CONT'D)

SUGGESTED SALVAGE ANALYSIS CHECK LIST FOR
ITEM: TROUSERS, MEN'S, COTTON, OLIVE GREEN 107
Specification No. MIL-T-838F

	Fabric Failure					Seam Failure	
Location	**Holes**	**Tears**	**Frays**	**Wear Areas**	**Fading**	**Thread**	**Tears**
WAISTBAND							
Top							
Bottom							
Belt loops							
FRONT OPENINGS							
Left fly							
Right fly							
Bartacks							
Buttonholes							
Buttons							
CROTCH							
Fly to inseam							
SEAT							
Inseam to end of curve							
End of curve to waistband							
POCKETS							
Side:							
Right							
Left							
Back:							
Right							
Left							
BUTTONHOLES							
Thread worn or missing							
Fabric tears at ends							
BARTACKS							
Thread failure							
Fabric torn at bartack							

APPENDIX B

EXTRACT FROM

"ANALYSIS OF WORN GARMENTS - METHODOLOGY"
(amended)

by

William S. Cowie and Doris B. Robinson

1961

U. S. Army Natick Laboratories
Natick, Massachusetts

. . . The purpose of this paper is to report partial results of the most recent salvage study undertaken. Included in this study were the following five clothing items:

(1)	Trousers, Utility, Man's	400 pairs
(2)	Shirts, Utility, Man's	400
(3)	Coat, Man's, Field	300
(4)	Trousers, Shell, Field	300 pairs
(5)	Shirt, Man's, Field	300

The garments were visually screened and arbitrarily divided into the following categories:

(1) Wear and tear evident (including fading)
(2) Repairable defects
(3) No obvious defects

It has been noted that although the garments had been salvaged, the examining technologists felt that a considerable number of them fell into the second and third categories, as evidenced by the information contained in Table I.

TABLE I. NUMBER OF GARMENTS SHOWING EITHER NO DAMAGE OR REPAIRABLE DAMAGE

	No Obvious Defects	Repairable Defects
Shirts, Utility	30	0
Trousers, Utility	24	0
Trousers, Shell, Field	46	90
Shirt, Man's Field	0	70
Coat, Man's, Field	43	61

After the screening process the study was divided into two phases. The first consisted of scoring the wear on the garments as measured by the presence of holes, tears, frays, and abrasion. This scoring was based on the existing wear score system used for garments worn on the accelerated wear course.

The second phase consisted of detailed visual examination of randomly selected (from the group) garments which showed definite wear and tear. In all, 50 each of the utility trousers and shirts were chosen for inspection and evaluation and 30 each of the three remaining items. The results of this examination are given below.

Trousers, Utility

It became evident early in the examination of these trousers that a definite wear pattern existed on this garment. Almost without exception the front pocket showed some degree of fraying at the edge, most of it

severe. Table II summarizes the number of garments showing this characteristic pattern.

TABLE II. INCIDENCE OF POCKET OPENINGS SHOWING FRAYING

	One Pocket Frayed	Both Pockets Frayed
Number of Pairs of Trousers	5	33

In addition, many of the garments showed holes and tears which appeared to be purely fortuitous in nature (that is, due to snagging) or, in a few instances, to exposure to chemical damage such as might be caused by battery acid. The distribution of these damages over the garment was random in nature except for the fact that there was a preponderence on the front of the garment. Microscopic analysis of some representative trousers indicated no significant degree of fabric weakness adjacent to the areas of tears and holes. The statements made above are equally applicable to the other four garment types inspected, except as otherwise noted later.

Shirts, Utility

As in the case of the utility trousers, a definite wear pattern was observed on the utility shirts. Definite fraying was noted at the fold of the collar. Of the 50 garments examined 36 exhibited this fraying and most of those which did not, had obviously been salvaged while still reasonably new as a result of fortuitous holes and tears.

Shirt, Man's, Field

Of the 5 items examined, the wool shirt showed less overall wear than any of the others. All of the garments appeared to have been salvaged as a result of accidents. The only characteristic other than fortuitous damage was evidence of pilling. This was particularly noticeable in the area of the back of the sleeve and on the collar. Altogether 14 of the garments showed pilling in one or more locations.

Trousers, Shell, Field

These trousers showed a considerable amount of wear, and several wear patterns were encountered. The first of these was fraying of the pocket flaps both in the front and back. Of the 30 garments examined 17 demonstrated this failure. Secondly, holes and severe abrasion were noted at the location of the snap fastners on the pockets. In all, 19 garments were so affected. Finally, 7 of the garments showed that the seam of the lower back pocket had pulled away at the edge of the

pocket. In the opinion of the Chief, Seams Engineering Laboratory, this was not a seam failure as such but was due to the strain caused by the snap fastner when opening and closing the pocket flap. As in the other garments examined, many holes and tears were scattered randomly throughout the total area.

Coat, Man's, Field

As in the field trousers, three distinct wear patterns were seen in the coats. Of the 30 garments 20 evidenced severe fraying at the cuffs. Of these 20, 12 were frayed to the point of actual separation. Secondly, holes and severe abrasion were noted along the sleeves of 9 of the garments inspected. Finally, there was evidence of fraying at the lower edge of the garments around the drawstring and the lower pockets on 25 of the 30 garments. Other holes and tears were located randomly over the garments.

Conclusions

From the results of the examination of the five clothing items several conclusions may be drawn as follows:

(1) Some clothing items are salvaged when. . .they should not be--at least on the basis of wear.

(2) The fabrics and construction of such Army clothing are so well balanced that today there are few obvious points of weakness which could be corrected. Accordingly, much of the damage which brings Army clothing items to the salvage pile today is of a fortuitous nature, such as snagging, localized abrasion over rough surfaces, or exposure to chemicals.

(3) Over and beyond this fortuitous damage certain wear patterns can, however, be detected. Proper evaluation of corrective action to affect these kinds of failure requires particular care in analysis.

(4) Loss in color still appears to be a substantial reason for salvage. Much of this loss of color is not due to actual loss of dye, but attributable to abrasion which causes fiber ends to protrude from the fabric, thereby giving diffused light reflection. It is likely that in some cases camouflage effectiveness could be impaired before a uniform is normally worn out.

APPENDIX C

IDENTIFICATION OF CLOTHING FAILURES

1. Seams and Stitchings

Seams fail in the following ways:

a. Stitching (thread) broken or missing - The cause may be tension, insufficiently strong thread, or excessive wear on the thread where it is on the surface of the garment. (Curved stitching, when pulled straight, will generally break the thread.)

b. Fabric tears along or adjacent to the stitching - The cause may be the sewing operation itself.

c. Seam frays - Sometimes the cut edge of the fabric ravels and the stitching or thread is pulled out of the ravelled edge.

d. Yarn severance breaks - Protruding ends of the fabric yarns may be cut by the needles and show on the surface of the fabric, along the line of stitching, giving an objectionable appearance.

2. Bartacks

Bartacks fail in the following ways:

a. Sewing thread broken or missing - The cause may be tension or wear

b. Fabric tears at the ends or side of the bartack

3. Buttonholes

Buttonholes fail in the following ways:

a. Thread missing - This is caused by wear

b. Thread pulled off edge of the fabric surrounding the buttonhole.

c. Fabric tears at the ends of the hole

4. Button (stitching)

Associated with button problems are:

a. Thread failure

b. Tearing of the fabric onto which button was stitched

IDENTIFICATION OF CLOTHING FAILURES

5. Fabric failures

Fabrics fail in the following ways:

a. Wear areas - Areas in which one or more yarns are broken as a result of abrasion

b. Holes - Threads are missing in either or both directions W & F

c. Tears - A break, snag or burst caused by excessive tension and/or wear

d. Frays - Linear wear along facing or edge

6. Finish failures

Failures among fabric finishes are as follows:

a. Loss of color

b. Loss of protective or functional finishes

APPENDIX D

SAMPLE REPORTS OF SALVAGE ANALYSIS

from

"SALVAGE IN WESTERN PACIFIC"

conducted by

The Quartermaster Board

Fort Lee, Virginia

15 April 1946

CONTENTS

I. SAMPLE

1. Introduction.--In addition to a presentation of the findings resulting from a statistical analysis of the data obtained during the conduct of the study, there are assembled in this section of the report all other factors which serve to identify the type of sample from which the findings were derived as well as supplementary information obtained from interview of depot personnel. These factors are discussed in the following paragraphs.

2. Size of Sample.

a. A sample size of 500 for each item was arbitrarily adopted as a working goal. It was considered that a sample of 500 would be more than adequate to provide a representative picture of each item under study. If time and additional samples were available after 500 chartings had been obtained on every item, samples then would be increased above 500, first on high priority items, and then on medium priority items. No attempt was to be made to increase low priority items above the 500 figure. No chartings were to be obtained on "very low" or "incidental" priority items.

b. It was recognized that the upper limit of the sample size of any item would be governed by the availability of that item in the theater. In the application of the proposed plan, the non-availability of certain items precluded the possibility of obtaining a sample of 500 on all items.

c. In each of the subdivisions to this section of the report that follows, the size of the sample that was used for statistical analysis is indicated. Comparison of the size of samples shown with those previously given in the preliminary report submitted to the theater may disclose a slight variation in the sizes of the two samples. Smaller counts in this report resulted from discarding certain charts of failures upon which the information recorded did not meet all of the requirements of sample selection; larger counts are the result of miscounting by charting personnel while in the field.

d. Also to be found in the later subdivisions of this section will be an indication as to whether or not the sample size for each item is considered to be representative. In several instances, where the number of items charted was not sufficient to serve as a basis for statistical findings, the information obtained from charting the failures found in these items was used solely as support for observations obtained by interview of depot personnel.

e. Although the limited availability or non-availability of certain items was the most important single factor in determining the

upper limits of the size of the samples, nevertheless there were other restrictive factors. The rigid standards of selection employed for accumulation of the sample often resulted in an intensive rather than an extensive sample. At many installations, the great influx of excess clothing and equipment received from deactivated units reduced the percentage of salvage turned in as a result of fair wear and tear to as little as 5% of the total received. The prompt processing and disposition of Class "D" (unserviceable-unrepairable) items at most of the salvage installations visited resulted in little or no stockpiling of such materials. Since the rate of turn-ins on Class D salvage was exceedingly slow, the time factor became another limitation.

3. Nature of Sample.

a. A consideration directly related with the correct interpretation of the findings is the nature of the sample from which the data were obtained. In general, the sample was composed of Class D (unrepairable and unserviceable) items found in salvage. However, in addition to indicating the size of the sample, a complete description of the sample is given for each item. For example, it is possible to determine whether the frequency of failures indicated for an item are those found in samples of the items that were in the last stages of usefulness or whether the sample represented items that were in a condition of partial wear and tear but which nevertheless were salvageable as Class D.

b. The specific standards of selection that were used for each item are described in each of the following subdivisions to this section of the report.

4. Analysis of Sample.--The nature of the statistical analysis employed is described in the following paragraphs:

c. On those items where the sample size was considered representative, the findings are based on the complete and detailed tables of the statistical analysis of the locations and types of all failures found in each item. These tables are presented in Appendix "B", Exhibits A to Y.

(1) Three separate methods were used in the tabulation and analysis of salvage failures. For easy reference, these methods are referred to as Types I, II, and III. For explanatory purposes, the analysis of Jackets, HBT is used with pertinent extractions from the statistical appendix.

b. The Type I analysis gives two things: first, the number of items which failed at each specific location; and second, the number of

items which contained each specific type of failure. This analysis is on an item basis and does not consider the frequency of failures.

(1) Of a total of 524 HBT Jackets charted, 397 contained failures (one or more of any type) in the area designated as "Upper Body of Back". Expressed as a percentage, 75.8% of the 524 jackets sampled failed in the upper body of the back. It will be noted that whenever practicable locations of this type are in descending order of importance according to the percent of sample failing at each location.

TYPE I ANALYSIS

NUMBER OF JACKETS
FAILING AT EACH LOCATION

Locations of Failures	Number Failing	Per cent of Sample
Upper Body of Back	397	75.8%
Collar Fold	239	45.7%

(2) Of the 524 HBT Jackets sampled, 380 contained holes (one or more of any size) or 72.5% of the sample contained holes. Here again the failures are listed in descending order of importance whenever this method is considered practicable.

TYPE I ANALYSIS

NUMBER OF JACKETS
WITH EACH TYPE OF FAILURE

Types of Failures	Number Failing	Per cent of Sample
Holes	380	72.5%
Tears	371	70.8%

c. The Type II analysis gives the number of items containing each type of failure at each specific location. This analysis is also on an item basis and does not consider the frequency of failures.

(1) One hundred and seventy-five HBT Jackets contained holes (one or more of any size) in the "Upper Body of the Back". This is 33.4% of the sample of 524 jackets. There were 237 jackets, 45.2% of the sample, containing tears (one or more of any length and any direction) in this same location, upper body of the back.

(2) In addition, this analysis gives for each specific location the number of items containing holes and wear of each size and tears of each direction. Note in the following example that totalling the number failing with holes of the three sizes will not provide a figure equal to the number of jackets having this failure as shown at the extreme left of the chart. This is due to the fact that many jackets charted had more than one size of hole at each of the locations listed.

(3) The locations of failures are listed on these tables according to the relative positions of the various components of the item, rather than by descending order of importance.

TYPE II ANALYSIS

NUMBER OF JACKETS WITH EACH TYPE OF FAILURE AT EACH LOCATION

Locations of Failures	Types of Failures: Holes		Tears		Size of Holes: ¼" and Less		¼" to 1½"		Over 1½"	
	Number Failing	Per cent of Sample	Number Failing	Per cent of Sample	Number Failing	Per cent of Sample	Number Failing	Per cent of Sample	Number Failing	Per cent of Sample
Upper Body-Back	175	33.4%	237	45.2%	70	13.4%	112	21.4%	27	5.2%
Middle Body	40	7.6%	66	12.6%	21	4.0%	15	2.9%	4	.8%

d. The Type III analysis gives the number of each type of failure occurring at each specific location. This is the only analysis which is not on an item basis but rather considers the frequency of failures only.

(1) There were 3,761 individual failures found in the 524 HBT Jackets sampled.

(2) Nine hundred and seventy individual failures were found in the upper body of the back. Of all failures in all jackets, therefore, 25.8% were located at this specific location. Referring to the Type I analysis, it is shown that these 970 failures occurred in the 397 jackets failing at the upper body of the back.

(3) Of the 970 failures, 377 were holes, 407 were tears, and the remaining 186 failures were of miscellaneous types.

(4) Going further, the type III analysis reveals that of the 377 holes in the upper body of the back, 138 were ¼" or less in size,

204 were $\frac{1}{4}$" to $1\frac{1}{2}$", and the remaining 35 holes were over $1\frac{1}{2}$".

(5) As with the Type II analysis, the locations of failures are listed according to the construction of the item rather than in descending order of importance.

TYPE III ANALYSIS

FREQUENCY OF EACH TYPE
OF FAILURE AT EACH LOCATION

Locations of Failures	Types of Failures				
			Size of Holes		
	Holes	Tears	$\frac{1}{4}$" and Less	$\frac{1}{4}$" to $1\frac{1}{2}$"	Over $1\frac{1}{2}$"
	No. of Failures	No. of Failures	No. of Failures	No. of Failures	No. of Failures
Upper Body-Back	377	407	138	204	35
Middle Body	84	84	41	37	6

e. Each of these three methods of analysis supports the others. When used in the interpretation of failures found in salvage items, one method cannot be used to the exclusion of the others -- they must be considered together. For example, in the written analysis of the data which follows, information obtained from Type II and Type III analyses is presented as a combined figure. This figure is the average number of failures of a specific type which occurred at a particular location. Specifically, reference to the examples used above illustrating the Type II and Type III analysis shows that 175 HBT Jackets failed due to holes in the upper body of the back, and that a total of 377 failures of this type were charted at that location. By dividing the total number of failures (377) by the number of jackets containing this failure (175), an average figure of 2.2 holes per jacket failing is obtained. This average figure is employed in the written findings whenever it is considered advisable to point out not only the number of items failing (expressed as a percent of the total sample) but also the average frequency of failures. This is done for only those failures that could occur more than once at a specific location. Many types of failures charted are of such nature that only one failure of the type could be charted for each location. In such cases a combined figure is not used.

f. All items under study which were charted in sufficient quantity for statistical analysis were analyzed by the Type I and Type II methods. When considered valuable, the Type III analysis was also included. The frequency (Type III) analysis gives numerical weight to all failures and on certain items it indicates the relative severity of

locations and types of failures. Comparisons of frequency of failures alone can be misleading and must always be tempered by the other methods which are based on the "number of items failing".

5. Scope of Analysis.--With the mass of raw data collected in this study it was possible to make numerous types of statistical analyses and sub-analyses. However, in the interest of clarity and preciseness the presentation of this data has been limited to basic statistical procedures. Although they are concise, the statistical analyses are sufficiently comprehensive to present the data in its most significant aspects. In the written findings of the report an attempt has been made to limit discussion to major locations and types of failures, thus high-lighting the principal results of this study. Therefore, the written findings do not cover all of the detailed statistics presented in Appendix B. Thus the basis for all the written findings, together with supplementary statistical data not covered by the written findings, are included in Appendix B of this report.

6. Interviews.

a. To supplement the information obtained from charting failures of the study items, and to provide primary information in those cases where a sufficient sample of several items were not available, depot personnel were interviewed to obtain their observations on the wearability and suitability of the items being studied.

b. To eliminate repetition, since observations obtained from interviews are in many cases identical with statistical findings, information obtained in this manner is presented only when contradictory observations are made or when interview observations support a finding of particular importance. This information is in the report for the item concerned.

CANVAS AND WEBBING ITEMS

I. SIZE OF SAMPLE

1. The number of canvas and webbing items charted was as follows:

Item	Priority	Manila	Leyte	San Fernando	Total
Haversack, M-1928	High	486	18	323	827
Cover, Canteen, DSMTD., M-1910	High	202		535	737
Belt, Cartridge, Cal. .30, DSMTD., M-1943	High	97	8	174	279
Bag, Duffel	Medium	417		192	609
Carrier, Shovel, Intrenching, M-1943	Medium	114		373	487
Cover, Cot	Medium	517			517

2. The following items were not sampled because they were available only in small quantities. An effort was made to obtain information on these items by interview of depot personnel, but they had not had sufficient experience with the items to provide a satisfactory source of information.

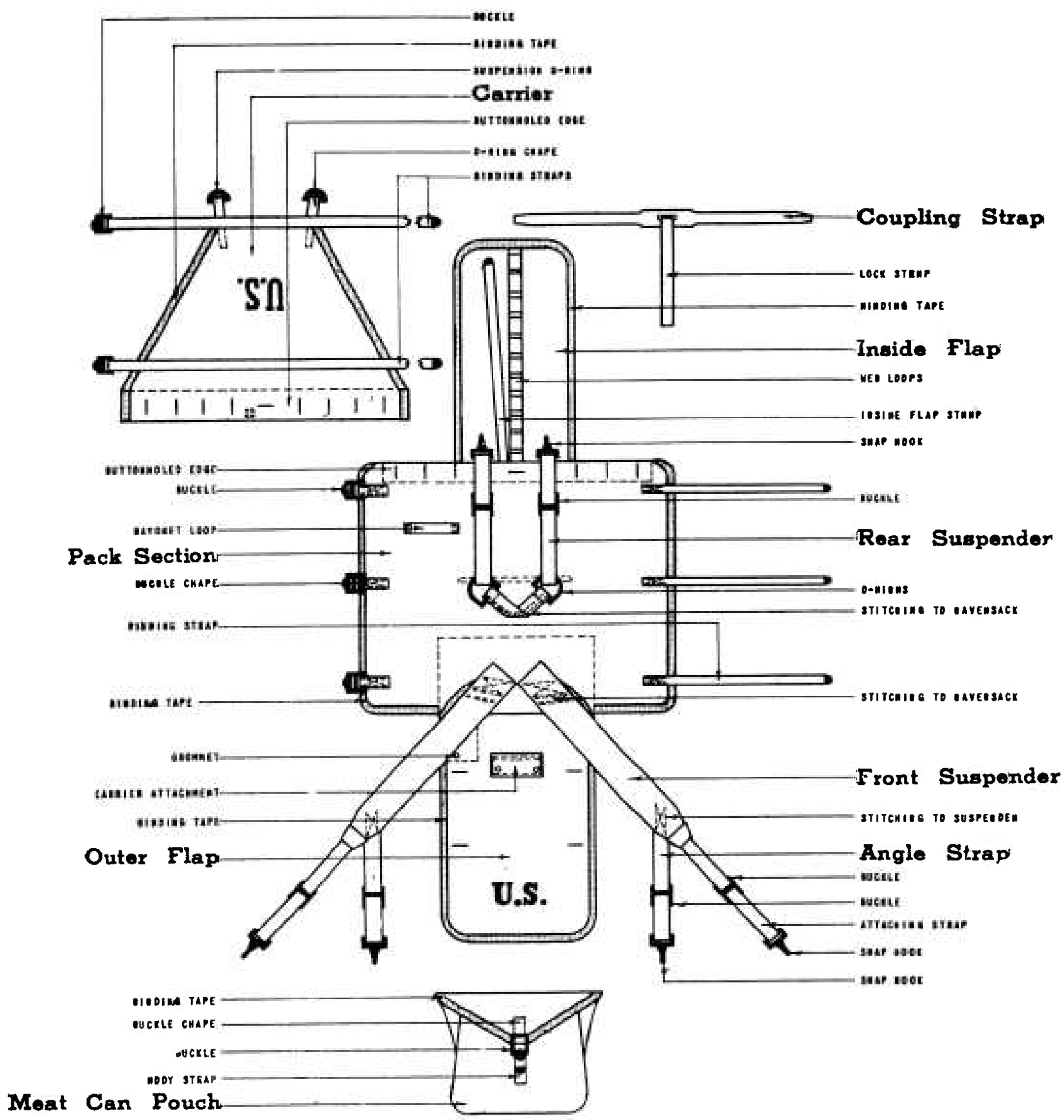
Priority	Item
High	Pack, Field, M-1943
High	Pack, Field, Cargo & Combat, and Suspenders, Pack, Field, Cargo & Combat
Low	Carrier, Grenade, 3-Pocket
Low	Bag, Carrying, Ammunition

II. Nature of Sample

At Manila, webbing items included in the sample were selected from the daily turn-in of salvage from using organizations; whereas at San Fernando, the sample was obtained from stock which had been stored, awaiting final disposition. At both installations the sample was selected from items which had failed due to normal wear and tear. Mildew and rot were found to be the predominant failures in all webbing items;

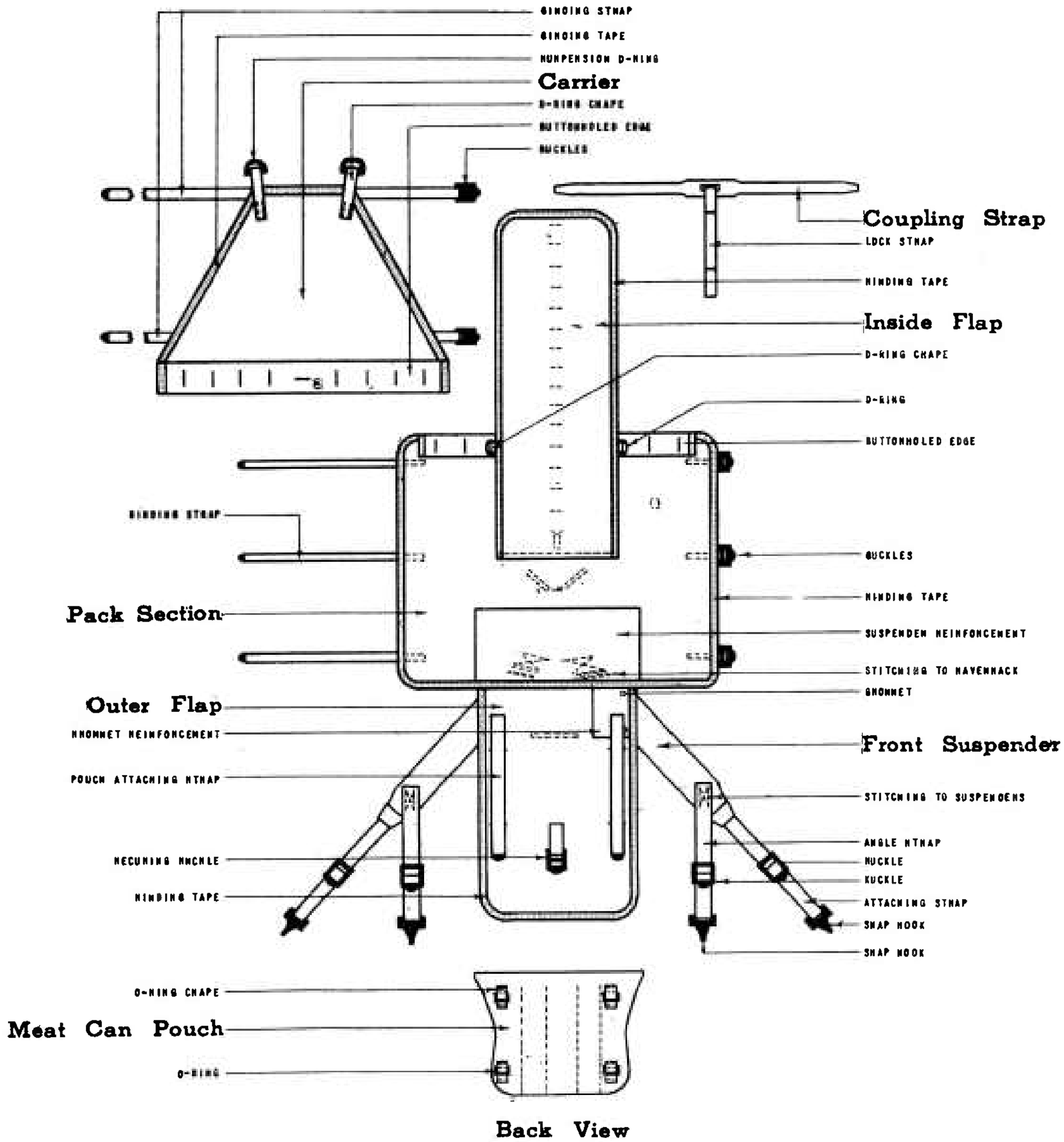
however, since the primary objective of the study was to determine construction defects in the webbing item, these failures were not recorded unless construction failures were also present. The decision not to chart items having only mildew and rot was based on the fact that the inclusion of such data would minimize the importance of construction failures found. It was not possible to determine whether the salvage had resulted from use under combat conditions or use in garrison. Specific conditions affecting the nature of the sample are discussed, where applicable, in the report on that item.

HAVERSACK, M-1928



Front View

HAVERSACK, M-1928



a. Nature of Sample.--Although the sample of haversacks selected was taken from stocks classified as class D (unserviceable) it was found that many of the items so classified had not reached the end point of usefulness. These items were classified in this manner because the minor failures that existed in the items were such that the haversacks could not be returned to stock and could not be reissued to troops because of decreased troop strength in the area.

b. General Failures.--Hardware corrosion, mildew, rot and fading were failures which were general in nature. Hardware corrosion was found in 88.6% of the haversacks inspected. No distinction was made as to whether all or part of the hardware was corroded on each haversack. Mildew and rot were present in 39.2% of the haversacks inspected. These were considered together because they were related failures which were usually present together in the same item. Mildew and rot usually affected the entire haversack but in the few cases where it was localized it was considered as a general failure because the area affected was a matter of chance rather than susceptibility. Fading affected 29.1% of the haversacks inspected and always affected the entire haversack when found. Nearly all haversacks examined had some degree of fading and only those which had excessive fading in the judgment of the person charting were charted as being faded.

c. Locations of Failures.--Failures other than general failures were tabulated by location and by type within each location. The component parts of each location were each separately tabulated as well. The following graph shows the percentage of the sample tabulated which contained failures at each location (all components). (Refer to Exhibit "L", Appendix "B", for detailed statistical analysis.)

d. Construction Failures.

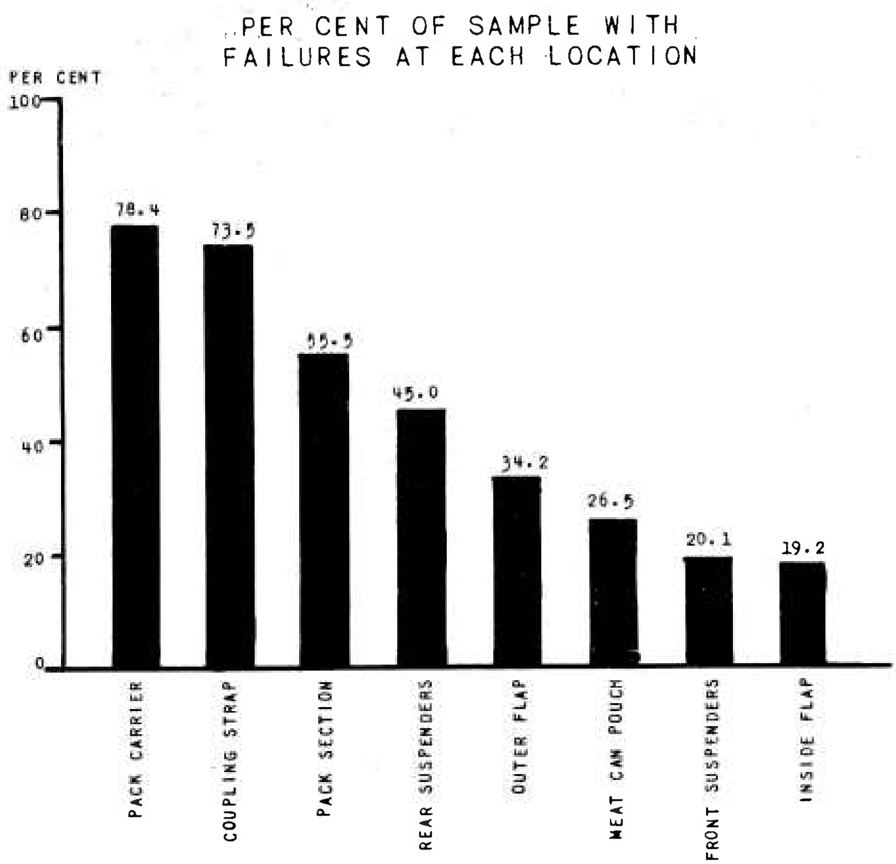
(1) Pack Carrier Failures.

(a) Body--The bodies of the pack carriers were missing on 74.2% of the haversacks inspected. It was not possible to determine what portion of the missing pack carriers was lost or discarded in the field since it was the practice of the salvage depots to remove those pack carriers that were in a serviceable condition and to return them to stock, even though the pack sections were unserviceable.

(b) Coupling Straps.--Coupling straps were missing on 73.5% of the haversacks examined. As the purpose of the coupling straps is to attach the pack carrier to the haversack, the reasons for its being recorded as missing are the same as those explained in the preceding paragraph.

(2) Pack Section Failures.--The principal failures found in the pack section of the haversacks sampled are shown in the following

table: (Failures affecting 5% or more of the sample are presented.)



PACK SECTION FAILURES

Type of Failure	% of Sample
Tears	23.0
Holes	14.9
Button Hole Frays	10.5
Seam Tears	8.9
Button Hole Tears	6.7

(a) Tears and holes were the most prevalent failures of the pack section. Most of these failures were found in the single fabric body of this section, but a few were found at the suspender reinforcement area and buttonhole edge which are both of double fabric construction.

(b) Button hole fray and button hole tears were found frequently. The button holes through which the coupling strap is threaded to attach the pack carrier are cut in canvas of double thickness

but the stitching with which they are finished is light.

(c) Seam tears were found in the canvas at points of strain where chapes, binding straps, front suspenders and rear suspenders were sewed to the pack section.

(d) Other failures charted were of minor importance and occurred in less than 5% of the sample.

1. Binding strap tips were missing in 4.8% of the sample. These were the result of either a failure of the hardware or a failure of the binding strap webbing.

2. Fray was found along the edge of the pack section containing the button holes and along the edge of the binding straps. This occurred in only 3% of the sample.

3. When buckles, buckle chapes, bayonet loops and binding straps were missing, they were charted only as missing, since it was impossible to determine the true reason for their absence. It might be assumed, however, that the stitching binding chapes, bayonet loops or binding straps to the canvas of the pack section had failed in these cases. This type of failure was charted in 1.7% of the sample.

4. Stitching failures were found at the bayonet loops, buckle chapes, binding straps and suspender reinforcements, but these failures, including stitching failures of the body of the pack section, were found in only 1.3% of the sample.

5. Binding tape failures occurred in only .7% of the sample.

(3) Rear Suspenders.--Most of the haversacks examined had two rear suspenders but 46 of the 827 examined had been made with only one rear suspender. Rear suspenders were missing on 43.5% of the haversacks inspected. In these cases the failure was not tabulated as a stitching failure because discussion with salvage personnel and the frequency of this failure indicated that the rear suspenders were removed by men in the field. Opinions were expressed that the rear suspenders cut into the back of the soldier carrying the haversack. Other failures of rear suspenders were found in less than 2% of the haversacks examined.

(4) Outer Flaps.--Failures were found in the outer flap of 34.2% of the haversacks examined. Failures occurring in 2% or more of the haversacks at this location are shown in the following table:

OUTER FLAP FAILURES

Type of Failure	% of Sample
Grommet Pulled or Missing	15.4
Tears	10.3
Holes	7.1
Button Hole Tears	4.2
Button Hole Frays	2.3

(a) Grommets were located in a reinforced area for attachment of the bayonet and in the carrier attachment. In nearly all instances where grommets were found pulled or missing, the failure was of the bayonet grommets in the reinforced area.

(b) All tears and holes in the outer flaps were in the single thickness of fabric.

(c) Button hole tears and button hole frays were found in the holes cut in the outer flap through which the "D" rings of the meat can pouch were inserted. These button holes were cut in single thickness canvas only and were finished with light stitching.

(d) Other failures of the outer flap including seam tears, binding tape failures, fray, missing strap tips, other missing parts and stitching failures were found in less than 2% of the haversacks inspected.

(5) Meat Can Pouch.--Failures were found in meat can pouches of 26.5% of the haversacks examined. Failures occurring in 2% or more of the sample at this location were:

MEAT CAN POUCH FAILURES

Type of Failure	% of Sample
Missing	12.1
Holes	5.4
Tears	5.0
Seam Tears	2.2

(a) The body or major section of the meat can pouch was missing from 10.8% of the haversacks examined. It should be pointed out that whenever a meat can pouch was tabulated as missing, the various component parts, such as "D" rings, buckles, etc., were not also tabulated as missing. "D" rings, buckles, body straps and buttons were

missing from meat can pouches in a few instances.

(b) Tears and holes were the primary defects but occurred in only 5% of the sample. Although this percentage is based on the total sample of 827 haversacks, the 89 missing meat can pouches would not greatly affect the percentage of failures. Other failures which were considered to be of minor importance were seam tears, button hole tears and frays, binding tape failures, stitching, fray and missing strap tips.

(c) Of the sample examined (827), thirty-six were made with button fasteners for the meat can pouch instead of buckle fasteners. Of these 36 pouches, nine were found with button hole tears and seven were found with button hole fray.

(6) Front Suspenders.--Failures were found in the front suspenders of 20.1% of the haversacks. Failures which were found in 3% or more of the sample failing at this location were:

FRONT SUSPENDERS FAILURES

Type of Failure	% of Sample
Missing	6.2
Frays	5.6
Broken	4.2
Stitching	3.5

(a) In only 0.6% of the haversacks examined were entire front suspenders missing, although in 5.6% of the sample parts of front suspenders were missing. These missing parts were:

FRONT SUSPENDERS, PARTS MISSING

Missing Part	% of Sample
Attaching Strap Body, Including Hooks and Buckles	.4
Snap Hooks (Attaching Strap)	1.2
Angle Strap Body, Including Hooks and Buckles	2.8
Snap Hooks (Angle Straps)	2.2
Buckle (Angle Straps)	.1

(b) Frays were found in the angle straps, the attaching straps, and the wide suspender webbing. The majority of such fray failures were found in the suspender webbing.

(c) Failures charted as broken were all failures of the snap hooks attached to the angle straps and attaching straps. Snap

hooks were considered as broken if the spring were missing. Bent snap hooks were also found in 2.9% of the sample.

(d) The majority of stitching failures were found where the front suspenders are sewn to the suspender reinforcement area of the pack section, although some stitching failures were found where the angle straps are sewn to the suspender body.

(e) Tears, holes and seam tears were infrequent.

(7) Inside Flap.--Of the haversacks examined, 19.2% had failures in the inside flaps. The inside flap strap was considered as part of the inside flap assembly. Failures of the inside flap occurring in 2% or more of the sample were:

INSIDE FLAP FAILURES

Type of Failure	% of Sample
Tears	7.0
Holes	6.8
Frays	2.4
Missing Strap Tips	2.2

(a) Most tears were found in the canvas of the inside flap but a few were found in the web loops.

(b) All holes found were in the canvas body of the inside flap.

(c) Frays were found principally in the binding tape and along the edge of the inside flap straps.

(d) Strap tips were missing on the inside flap straps of 2.2% of the haversacks examined. Though this percentage seems low at first glance, it is high in comparison with the percentage (4.8%) of pack sections having missing strap tips, since there are only one-third as many inside flap straps as there are pack section binding straps per haversack.

(e) Other failures of the inside flaps, including binding tape failures, missing parts, seam tears and stitching failures, were of minor importance.

e. Distribution and Frequency of Failures.

(1) A total of 2173 failures (exclusive of general failures

and missing sections) were found at all locations on the haversack, an average of 2.6 per item. Because of the numerous specific locations used in the type II analysis, it was considered advisable to group these locations by type of construction material in presenting the type III frequency analysis. Therefore, the table below shows the percent of total failures occurring in each type of material used in construction of the haversack.

PER CENT OF FAILURES CHARTED

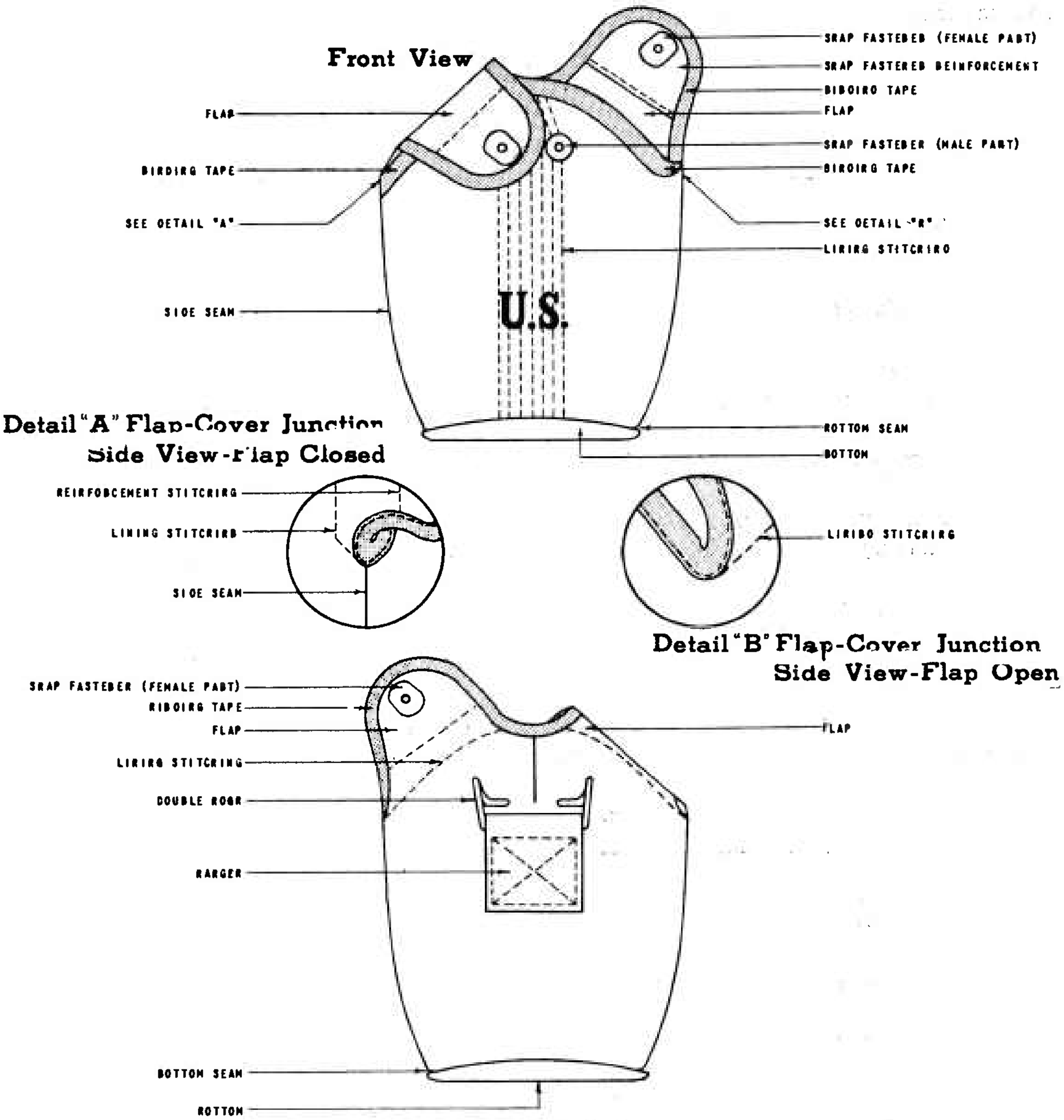
Material	Number	% of Failures
Canvas (Single Thickness)	1,164	53.5
Hardware	339	15.7
Canvas (Double Thickness)	336	15.5
Strap Webbing	172	7.9
Suspender Webbing (Wide)	103	4.7
Binding Tape	53	2.4
Web Loops	6	.3

(2) An analysis of those failures other than general failures and missing sections of the haversack is presented in the table below.

Type of Failure	% of Failures
Tears	21.7
Holes	18.8
Seam Tears	10.4
Button Hole Frays	9.6
Button Hole Tears	9.3
Grommets Pulled or Missing	8.8
Frays	6.2
All Others (Six Types)	15.2
TOTAL	100.0

2. Cover, Canteen

COVER, CANTEEN, DISMOUNTED, M-1910



Back View

a. Nature of Sample.--In general the canteen covers included in the sample were representative of covers failing due to fair wear and tear. In most instances the covers appeared to have been used to a considerable extent. Unlike other items of web equipment, the canteen cover is used extensively even under garrison conditions.

b. General Failures.--Failures which were not localized by area but tended to affect the entire cover (exclusive of the lining) were fading, hardware corrosion, mildew, and rot.

(1) Fading was charted only when it was considered to be excessive by the study team member examining the covers. Based on these standards, 53.2% of the canteen covers were charted as faded; however, fading in a lesser degree was present in most of the covers inspected. Fading was not considered a cause of salvage.

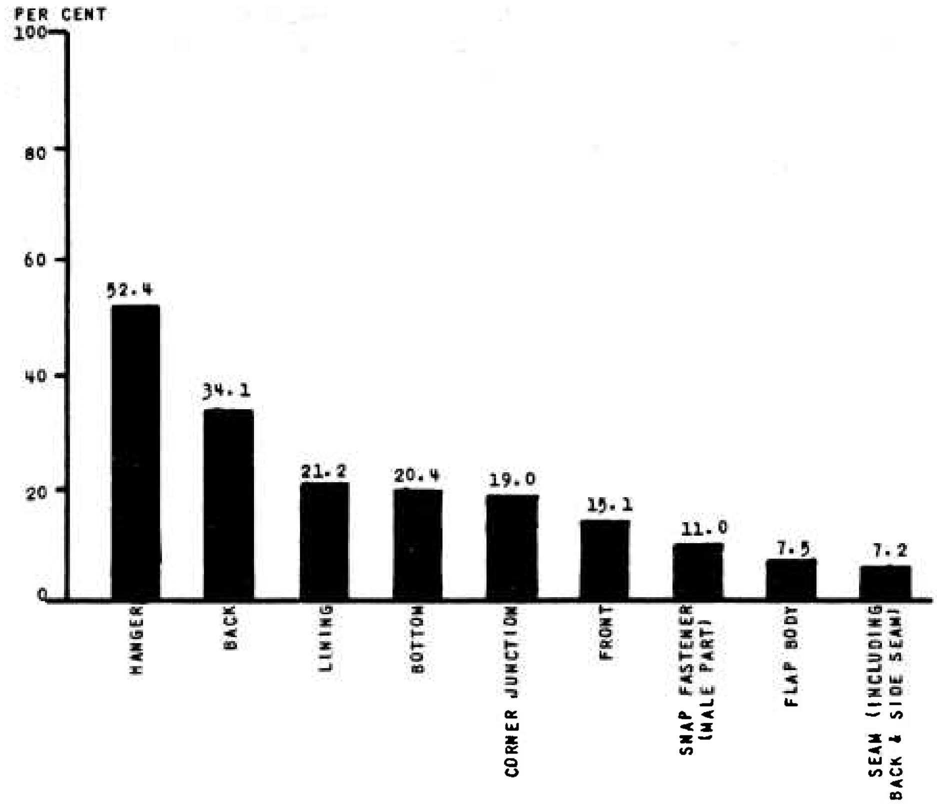
(2) Hardware corrosion was present in 44.6% of the canteen covers charted. It was impossible to determine whether the corrosion existed at the time of salvage or occurred during storage.

(3) Mildew was present in 22.1% of the covers charted. As with corrosion, it was not possible to determine whether mildew occurred prior to salvage or in storage.

(4) Rot was present in 11.8% of the canteen covers inspected. This rot occurred principally at the bottom and near the bottom of the covers. It was presumed that this might be due to frequent moistening of this part of the canteen cover without proper drying. Moisture adhering to the canteen when filled, sweating of the canteen, rain, and intentional wetting for cooling effect were ways in which the canteen cover may have been moistened.

c. Locations of Failures.--Those failures other than general failures were charted by specific location on the canteen cover. The chart below shows those locations at which more than 5% of the sample contained failures. (See Exhibit "M", Appendix "B" for detailed statistical analysis.)

PER CENT OF SAMPLE WITH
FAILURES AT EACH LOCATION



d. Distribution of Failures.--A total of 2138 failures not including general failures were found at all locations of the canteen cover, an average of 2.9 failures per item. The following table shows the distribution of these failures by location:

PER CENT OF FAILURES AT EACH LOCATION

Location	Number	% of Failures
Hanger	572	26.8
Back Body	508	23.7
Front Body	226	10.7
Bottom Body	210	9.8
Flap Body	198	9.2
Corner Junction	176	8.2
All Other 6 Locations (Less Than 5%)	248	11.6
TOTAL	2,138	100.0

e. Construction Failures.--In the following paragraphs the types of failures occurring at specific locations are discussed.

(1) Hanger.--The hanger was the location where failures of the canteen cover occurred most frequently. The principal failures found at this location were:

HANGER FAILURES

Failure	% of Sample
Seam Tears	31.1
Stitching	20.1
Frays	4.7

(a) The seam tears charted at this location were tears in the back body fabric at the point where the stitching attaching the hanger to the body was located. In many cases the stitching was strong enough to resist breakage when subjected to strain with the result that the fabric tore at this point. In other cases the stitching itself was broken. Although recent specifications require reinforcement of the hanger to prevent this type of failure, only a few covers were found with this reinforcement and as a result it was not possible to determine whether the reinforcement prevented these or similar failures.

(2) Body of Cover (Back).--In the back portion of the body of the cover 34.1% of the canteen covers had failures. The more important failures were:

BACK FAILURES

Failure	% of Sample
Holes	27.5
Tears	6.6
Wear Areas	4.5

(a) The back of the canteen covers near the botton was the area of greatest wear. Holes, tears, and wear areas occurred more frequently there than in any other part of the canteen cover. This was to be expected as this area is subject to much friction against the clothing and equipment of the soldier.

(3) Lining.--Failures in the lining were not recorded by specific locations or frequency of occurrence. The most important of the failures found at this location was felting of the lining, which occurred

in 48.0% of the sample. Felting was probably caused by the rubbing action resulting from inserting or removing the canteen and cup while the lining was wet. Felting was not a cause of salvage but as it became more pronounced it undoubtedly contributed to failure of the lining due to tears, which were charted in 21.2% of the sample.

(4) Bottom.--The bottom body of the canteen cover failed in much the same manner as the back body but in a smaller percentage of the covers charted. Principal failures were:

BOTTOM FAILURES

Failure	% of Sample
Holes	15.3
Wear Area	3.3
Frays	2.2

(5) Corner Junction.--At the juncture of the flap and front of the canteen cover, referred to as "corner junction" failures were varied. The principal failures at this location were:

CORNER JUNCTION FAILURES

Failure	% of Sample
Holes	10.7
Binding Tape	4.3
Frays	4.2
Seam Tears	2.0

(a) Nearly one-fifth of the canteen covers inspected had failures at this location. The covers do not fold smoothly at this point and the resulting pucker is exposed to greater wear action than a smooth surface would be.

(6) Front Area.--The front of the canteen cover is partly protected by overlap of the flaps and is not as exposed to wear as the back against clothing and equipment. The more important failures of this area were:

FRONT FAILURES

Failure	% of Sample
Holes	9.9
Tears	3.0
Snap Fastener Tears (Male Portion)	2.4
Binding Tape	2.1

(a) Snap fastener tears were charted in the front body area when the fastener was partially torn from the fabric. When the fastener (male portion) was completely torn from the fabric it was charted as missing. This occurred in 11.0% of the total sample.

(7) Flaps.--Flap failures were present in less than 10% of the canteen covers inspected. The principal failures at this location were:

FLAP FAILURES

Failure	% of Sample
Binding Tape	9.0
Holes	4.5
Snap Fastener Tears (Female Portion)	2.8

(a) As in the front body, snap fastener tears were charted in the flap body area when the snap fastener (female portion) was partially torn from the fabric. It was found to be missing or completely torn from the fabric of the flap in 2.4% of the sample.

(8) Seam (Including Back and Side Seams)--Of the canteen covers inspected, part had the seam down the back and part had the seam at the side. Of the covers inspected, 6.1% had stitching failures at the back and 5.6% had stitching failures at the side, or, 11.7% of all covers inspected had seam failures. No record was made of what part of the total sample had each type of seam. Seam tears were charted at this location in 2.3% of the sample.

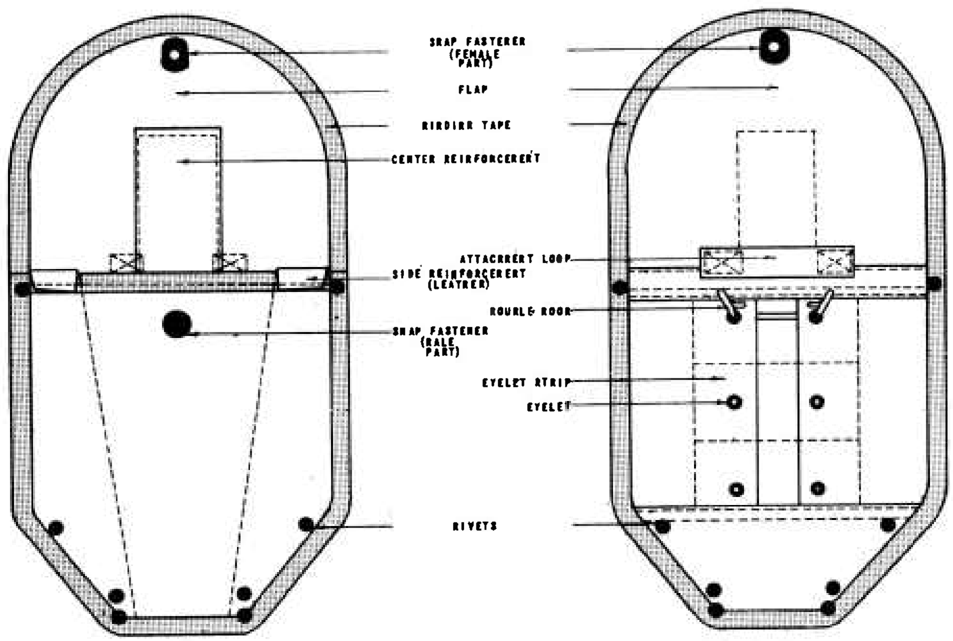
(9) Other Locations of Failures.--Double hook failures were found in only 2.7% of the canteen covers charted. Two percent were missing and 0.7% were bent. Stitching to lining at the front body failed on only 1.2% of the canteen covers inspected.

f. Frequency of Failures Charted.--An analysis of the 2138 failures charted is presented in the table following:

Type of Failures	% of Failures
Holes	37.9
Seam Tears	17.3
Stitching	13.3
Binding Tape	7.3
Missing	6.4
Frays	5.8
Tears	5.5
All Others (Four Locations)	6.5
TOTAL	100.0

5. Carrier, Shovel, Intrenching, M-1943.

CARRIER, SHOVEL, INTRENCHING, M-1943



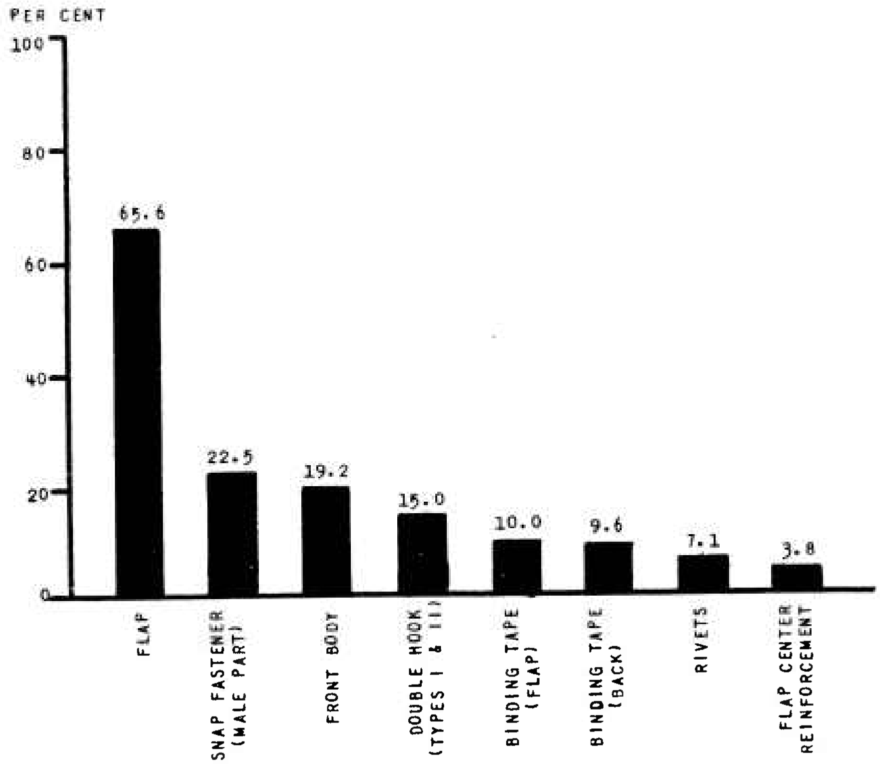
Front View **Back View**

a. Nature of Sample.--Examination of salvaged shovel carriers disclosed that two types were in use. The two types are designated in this report as Type I and Type II, Type I being those carriers which had three pairs of eyelets in the back permitting the double hook to be adjusted to various positions and Type II being those which had a fixed hanger attaching the double hook to the carrier. In view of the difference in construction between the two types at this location, separate tabulation was made for each; however, a combined tabulation

was made for all other locations. Although a total of 487 carriers were charted, tabulations which follow are based on a sample of 448 since 39 of the carriers contained only general failures; i.e., hardware corrosion, mildew or fading.

b. Location of Failures.--The following chart shows those locations on the carrier at which 3% or more of the sample failed. (Refer to Exhibit "P", Appendix "B" for a detailed statistical analysis.

PER CENT OF SAMPLE WITH
FAILURES AT EACH LOCATION



c. Distribution of Failures.--A total of 965 failures were charted in the 448 carriers, an average of 2.2 failures per item. The table at the top of the next page shows the distribution of these failures by location.

d. Flap.--The flap was the area most exposed to wear and had more failures than any other part of the carrier. Fifty percent of the sample contained holes in this area and 6.5% contained tears. Holes were not important as a primary cause of salvage because most holes were

PER CENT OF FAILURES AT EACH LOCATION

Location	Number	% of Failure
Flap Body	446	46.2
Front Body	122	12.6
Side Reinforcement	101	10.5
Binding Tape (Flap)	60	6.2
Rivets	48	5.1
Binding Tape (Back)	46	4.8
All Others (Eleven Locations)	142	14.6
TOTAL	965	100.0

small in size, but the presence of such a large number of holes indicates this as the point of greatest wear. Holes were classified according to size as follows:

SIZE OF HOLES IN FLAP

Size	% of Sample
$\frac{1}{4}$" or Less	39.5
$\frac{1}{4}$" to $1\frac{1}{2}$"	17.2
Over $1\frac{1}{2}$"	0.9

(1) Another important cause of failure in the flap area was failure of the fabric surrounding the snap fasteners (female portion). The fabric around the fastener was torn so that the fastener was separated from the fabric. In 2.2% of the sample, the fastener was missing which indicated that the tear had extended completely around the fastener. Where the tear only partly encircled the fastener, it was charted and tabulated as a snap fastener tear. This type failure was found in 11.6% of the sample. It was noted that sand and corrosion in the female portions of the fasteners made them difficult to open and doubtless contributed to failure.

e. Front Area.--Tears and holes were again the primary failures of the front area of the carriers. Holes were charted in 8.5% of the sample and tears were found in 5.6%. Holes were small as a rule and therefore not a primary cause of salvage.

(1) Snap fastener tears were also present in the front area. Missing fasteners were charted in 22.5% of the sample and tears partly encircling the fastener were found in 6.0% of the sample. It should be noted that a greater number of male section of fasteners were missing (from the body) than female sections of the fasteners (from the flap).

f. Double Hook.--Double hook failures were not important as a primary cause of salvage. Of the shovel carriers sampled, double hooks were bent in 14.5% of the carriers. In most cases, the bending was not great enough to interfere with proper functioning of the hook and even more severe cases could be straightened with two pairs of pliers. Hooks were missing from only 0.7% of the carriers inspected.

g. Binding Tape--Binding Tape failures were found in the flap of 10.0% and back of 9.6% of the carriers inspected. These failures were minor in nature and were not primary causes of salvage.

h. Rivets.--Rivets were pulled from the fabric in 7.1% of the carriers inspected. Though the number of these failures was not large, they were primary causes of salvage.

i. Center Reinforcement.--Center reinforcement failures were diversified and few in number. Failures were:

FAILURES OF CENTER REINFORCEMENT

Failure	% of Sample
Stitching	2.0
Holes	1.1
Tears	0.7
Seam Tears	0.2
Frays	0.2

j. Miscellaneous Failures.--The remaining parts, side reinforcement (leather), front center stitching, eyelet strip, eyelets, hangers, and top reinforcement had failures in less than 2% of the sample taken. Other than binding tape failures, the back body contained only failures of minor importance.

k. Frequency of Failures Charted.--An analysis of the 965 failures found at all locations on the carriers is presented in the following table:

Type of Failure	% of Failures
Holes	45.7
Missing	17.3
Snap Fastener Tears	8.3
Tears	7.7
Bent	7.1
Stitching	4.5
All Others (Four Types)	9.4
TOTAL	100.0

HAVERSACKS, M-1928
SAMPLE SIZE: 827

TYPE I ANALYSIS
NUMBER OF HAVERSACKS FAILING AT EACH LOCATION

LOCATIONS OF FAILURES	NUMBER FAILING	% OF SAMPLE
PACK CARRIER	648	78.4
COUPLING STRAP	608	73.5
PACK SECTION	459	55.5
REAR SUSPENDERS	372	45.0
OUTER FLAP	283	34.2
MEAT CAN POUCH	219	26.5
FRONT SUSPENDERS	166	20.1
INSIDE FLAP	159	19.2

TYPE I ANALYSIS
NUMBER OF HAVERSACKS WITH EACH TYPE OF FAILURE

	TYPES OF FAILURES	NUMBER FAILING	% OF SAMPLE
	MISSING	738	89.2
	TEARS	329	39.8
	HOLES	225	27.2
	GROMMET PULLED OR MISSING	127	15.4
	BUTTON HOLE FRAYS	106	12.8
	SEAM TEARS	99	12.0
	FRAYS	88	10.6
	BUTTON HOLE TEARS	85	10.3
	MISSING STRAP TIP	65	7.9
	STITCHING	49	5.9
	BROKEN	39	4.7
	BINDING TAPE FAILURE	36	4.4
	BENT	28	3.4
GENERAL	HARDWARE CORROSION	733	84.6
	MILDEW AND/OR ROT	324	39.2
	FADED	241	29.1

HAVERSACKS,
SAMPLE SIZE

TYPE II ANAL

NUMBER OF HAVERSACKS WITH EACH TYP

LOCATIONS OF FAILURES	TEARS		HOLES		SEAM TEARS		STITCHING		FRAYS		BUTTON HO FRAYS	
	NO. FAILING	% OF SAMPLE	NO. FAILING	% OF SAMPLE	NO. FAILING	% OF SAMPLE	NO. FAILING	% OF SAMPLE	NO. FAILING	% OF SAMPLE	NO. FAILING	% O SAMP
PACK CARRIER	14	1.7	3	.4	4	.5	1	.1	2	.2	1	.
BODY	11	1.3	3	.4	2	.2	1	.1				
BINDING STRAPS	3	.4							2	.2		
COUPLING STRAPS												
PACK SECTION	190	23.0	123	14.9	74	8.9	11	1.3	25	3.0	87	10.
BODY	180	21.8	119	14.4	60	7.3	2	.2				
BUTTON HOLE EDGE	4	.5	4	.5	2	.2			14	1.7	87	10.
BUCKLES												
BAYONET LOOP	2	.2			1	.1	2	.2				
BUCKLE CHAPES					6	.7	1	.1				
BINDING STRAPS	3	.4	1	.1	4	.5	3	.4	11	1.3		
SUSPENDER REINFORCEMENT	2	.2	9	1.1	3	.4	4	.5				
INSIDE FLAP	58	7.0	56	6.8	8	1.0	3	.4	20	2.4		
BODY	52	6.3	56	6.8	7	.8	3	.4	11	1.3		
INSIDE FLAP STRAP	2	.2							11	1.3		
WEB LOOPS	5	.6							2	.2		
"D" RINGS												
"D" RING CHAPES					1	.1			1	.1		
FRONT SUSPENDERS	15	1.8	1	.1	1	.1	29	3.5	46	5.6		
BODY	8	1.0			1	.1	23	2.8	41	5.0		
ATTACHING STRAP	3	.4	1	.1					3	.4		
BODY	3	.4	1	.1					3	.4		
SNAP HOOK												
BUCKLE												
ANGLE STRAP	6	.7					7	.8	10	1.2		
BODY	6	.7					7	.8	10	1.2		
SNAP HOOK												
BUCKLE												
REAR SUSPENDERS	1	.1					3	.4	1	.1		
BODY	1	.1					3	.4	1	.1		
SNAP HOOK												
OUTER FLAP	85	10.3	59	7.1	10	1.2	2	.2	5	.6	19	2.3
BODY	85	10.3	59	7.1	10	1.2	1	.1	2	.2	19	2.3
CARRIER ATTACHMENT							1	.1	3	.4		
BAYONET GROMMET REINFORCEMENT												
POUCH ATTACHING STRAPS												
MEAT CAN POUCH	41	5.0	45	5.4	18	2.2	5	.6	2	.2	7	.8
BODY	41	5.0	45	5.4	16	1.9	2	.2	2	.2	7	.8
"D" RINGS												
"D" RING CHAPES					1	.1	3	.4				
BUCKLE												
BUCKLE CHAPE					1	.1						
BODY STRAP												
BUTTON												

HAVERSACKS, M-1928
SAMPLE SIZE: 827

TYPE II ANALYSIS

OF HAVERSACKS WITH EACH TYPE OF FAILURE AT EACH LOCATION

2

TYPES OF FAILURES

TCHING		FRAYS		BUTTON HOLE FRAYS		BUTTON HOLE TEARS		BENT		BROKEN		MISSING		GROMMET PULLED OR MISSING		MISSING STRAP TIP		BI T FA
NG	% OF SAMPLE	NO. FAILING	% OF SAMPLE	NO. FAILING	% OF SAMPLE	NO. FAILING	% OF SAMPLE	NO. FAILING	% OF SAMPLE	NO. FAILING	% OF SAMPLE	NO. FAILING	% OF SAMPLE	NO. FAILING	% OF SAMPLE	NO. FAILING	% OF SAMPLE	NO. FAILING
	.1	2	.2	1	.1							615	74.4			7	.8	2
	.1											614	74.2					2
		2	.2													7	.8	
												608	73.5					
	1.3	25	3.0	87	10.5	55	6.7					14	1.7			40	4.8	6
	.2																	6
		14	1.7	87	10.5	55	6.7											
												2	.2					
	.2											2	.2					
	.1											4	.5					
	.4	11	1.3									7	.8			40	4.8	
	.5																	
	.4	20	2.4									9	1.1			18	2.2	10
	.4	11	1.3															10
		11	1.3									2	.2			18	2.2	
		2	.2															
												4	.5					
		1	.1									4	.5					
	3.5	46	5.6					24	2.9	35	4.2	51	6.2					
	2.8	41	5.0									5	.6					
		3	.4					9	1.1	9	1.1	13	1.6					
		3	.4									3	.4					
								9	1.1	9	1.1	10	1.2					
	.8	10	1.2					15	1.8	26	3.1	41	5.0					
	.8	10	1.2									23	2.8					
								15	1.8	26	3.1	18	2.2					
												1	.1					
	.4	1	.1					4	.5	4	.5	360	43.5					
	.4	1	.1									344	41.6					
								4	.5	4	.5	16	1.9					
	.2	5	.6	19	2.3	35	4.2					1	.1	127	15.4	4	.5	10
	.1	2	.2	19	2.3	35	4.2											10
	.1	3	.4											4	.5			
														126	15.2			
																4	.5	
	.6	2	.2	7	.8	9	1.1					100	12.1			5	.6	9
	.2	2	.2	7	.8	9	1.1					89	10.8					9
												1	.1					
	.4																	
												2	.2					
												5	.6			5	.6	
												3	.4					

EXHIBIT

Appendix B

B

FAILURE AT EACH LOCATION

OF FAILURES													
TTON HOLE TEARS		BENT		BROKEN		MISSING		GROMMET PULLED OR MISSING		MISSING STRAP TIP		BINDING TAPE FAILURE	
O. LING	% OF SAMPLE	NO. FAILING	% OF SAMPLE	NO. FAILING	% OF SAMPLE	NO. FAILING	% OF SAMPLE	NO. FAILING	% OF SAMPLE	NO. FAILING	% OF SAMPLE	NO. FAILING	% OF SAMPLE
						615	74.4			7	.8	2	.2
						614	74.2					2	.2
										7	.8		
						608	73.5						
55	6.7					14	1.7			40	4.8	6	.7
												6	.7
55	6.7												
						2	.2						
						2	.2						
						4	.5						
						7	.8			40	4.8		
						9	1.1			18	2.2	10	1.2
												10	1.2
						2	.2			18	2.2		
						4	.5						
						4	.5						
		24	2.9	35	4.2	51	6.2						
						5	.6						
		9	1.1	9	1.1	13	1.6						
						3	.4						
		9	1.1	9	1.1	10	1.2						
		15	1.8	26	3.1	41	5.0						
						23	2.8						
		15	1.8	26	3.1	18	2.2						
						1	.1						
		4	.5	4	.5	360	43.5						
						344	41.6						
		4	.5	4	.5	16	1.9						
5	4.2					1	.1	127	15.4	4	.5	10	1.2
5	4.2											10	1.2
								4	.5				
								126	15.2				
										4	.5		
9	1.1					100	12.1			5	.6	9	1.1
9	1.1					89	10.8					9	1.1
						1	.1						
						2	.2						
						5	.6			5	.6		
						3	.4						

EXHIBIT L-2

Appendix B

3

1

HAVERSACKS, M-1928
SAMPLE SIZE: 827

TYPE III ANALYSIS

FREQUENCY OF EACH TYPE OF FAILURE AT EACH LOC

LOCATIONS OF FAILURES	TYPES OF FAILURES										
	TEARS	HOLES	SEAM TEARS	STITCHING	FRAYS	BUTTON HOLE FRAYS	BUTTON HOLE TEARS	BENT	BROKEN	MISSING *	GROMMETS PULLED OR MISSING
	NO. OF FAILURES	NO. OF FAILURES	NO. OF FAILURES	NO. OF FAILURES	NO. OF FAILURES	NO. OF FAILURES	NO. OF FAILURES	NO. OF FAILURES	NO. OF FAILURES	NO. OF FAILURES	NO. OF FAILURES
CANVAS (SINGLE THICKNESS)	421	401	213	8	2	51	68				
CANVAS (DOUBLE THICKNESS)	7	14	8	1	17	156	133				
STRAP WEBBING	26	3		20	44						
SUSPENDER WEBBING (WIDE)	9		1	32	61						
BINDING TAPE			1		10						
WEB LOOPS	5				1						
HARDWARE								33	52	64	190
FREQUENCY OF FAILURE BY TYPE OF FAILURE	468	418	223	61	135	207	201	33	52	64	190
PER CENT OF TOTAL FAILURES	21.7	18.8	10.4	2.9	6.2	9.6	9.3	1.5	2.4	2.9	8.8

* *This column does not include missing sections of the haversack*

HAVERSACKS, M-1928
SAMPLE SIZE: 827

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TYPE III ANALYSIS

FREQUENCY OF EACH TYPE OF FAILURE AT EACH LOCATION

TYPES OF FAILURES														SIZE OF HOLES		
HOLES	SEAM TEARS	STITCHING	FRAYS	BUTTON HOLE FRAYS	BUTTON HOLE TEARS	BENT	BROKEN	MISSING *	GROMMETS PULLED OR MISSING	MISSING STRAP TIP	BINDING TAPE FAILURE	FREQUENCY OF FAILURES AT EACH LOCATION		¼" OR LESS	¼" TO 1½"	OVER 1½"
NO. OF FAILURES	NO. OF FAILURES	NO. OF FAILURES	NO. OF FAILURES	NO. OF FAILURES	NO. OF FAILURES	NO. OF FAILURES	NO. OF FAILURES	NO. OF FAILURES	NO. OF FAILURES	NO. OF FAILURES	NO. OF FAILURES	NO. OF FAILURES	% OF TOTAL FAILURES	NO. OF FAILURES	NO. OF FAILURES	NO. OF FAILURES
401	213	8	2	51	68							1,164	53.5	145	206	50
14	8	1	17	156	133							336	15.5	4	8	2
3		20	44							79		172	7.9	2	1	
	1	32	61									103	4.7			
	1		10								42	53	2.4			
			1									6	.3			
						33	52	64	190			339	15.7			
418	223	61	135	207	201	33	52	64	190	79	42	2,173		151	215	52
18.8	10.4	2.9	6.2	9.6	9.3	1.5	2.4	2.9	8.8	3.6	1.9		100.0	6.9	9.9	2.4

* This column does not include missing sections of the haversack.

COVERS, CANTEEN
SAMPLE SIZE: 737

TYPE I ANALYSIS

NUMBER OF COVERS FAILING AT EACH LOCATION

LOCATIONS OF FAILURES	NUMBER FAILING	% OF SAMPLE
HANGER	386	52.4
BACK BODY	251	34.1
LINING	156	21.2
BOTTOM BODY	150	20.4
CORNER JUNCTION	140	19.0
FRONT BODY	111	15.1
SEAM (INCL. BACK AND SIDE SEAM)	93	12.6
SNAP FASTENER (MALE)	81	11.0
FLAP BODY	55	7.5
DOUBLE HOOK	20	2.7
SNAP FASTENER (FEMALE)	18	2.4
STITCHING TO LINING	12	1.6
BOTTOM SEAM	6	.8

TYPE I ANALYSIS

NUMBER OF COVERS WITH EACH TYPE OF FAILURE

TYPES OF FAILURES		NUMBER FAILING	% OF SAMPLE
HOLES		345	46.8
SEAM TEARS		265	35.9
STITCHING		210	29.8
LINING TEARS		156	21.2
PARTS MISSING		104	14.1
TEARS		84	11.4
BINDING TAPE FAILURES		80	10.9
FRAYS		80	10.9
WEAR AREAS		45	6.1
SNAP FASTENER TEARS (FEMALE)		21	2.9
SNAP FASTENER TEARS (MALE)		18	2.4
FRAY TEARS		5	.7
BENT (HOOKS)		5	.7
GENERAL FAILURES	FADING	392	53.2
	HARDWARE CORRODED	329	44.6
	MILDEW	163	22.1
	ROTTEN	87	11.8
	LINING FELTING	354	48.0

1

NUMBER OF COVERS WITH

LOCATIONS OF FAILURES		TEARS		HOLES		STITCHING		FRAYS	
		NO. FAILING	% OF SAMPLE	NO. FAILING	% OF SAMPLE	NO. FAILING	% OF SAMPLE	NO. FAILING	% OF SAMPLE
FRONT	BODY	22	3.0	73	9.9			5	.7
	SNAP FASTENER (MALE)								
	STITCHING TO LINING					9	1.2		
BACK	BODY	49	6.6	203	27.5	2	.3	7	.9
	SEAM (INCL. SIDE SEAM)					86	11.7		
	HANGER	2	.3	4	.5	148	20.1	35	4.7
	DOUBLE HOOK								
FLAP	BODY	6	.8	33	4.5	3	.4	2	.3
	SNAP FASTENER (FEMALE)								
	CORNER JUNCTION	5	.7	79	10.7			31	4.2
BOTTOM	BODY	3	.4	113	15.3			16	2.2
	SEAM					3	.4		
LINING	FELT LINING	156	21.2						

NUMBER OF CANTEEN CO

LOCATIONS OF FAILURES		DIRECTION OF TEARS				
		HORIZONTAL		VERTICAL		
		NO. FAILING	% OF SAMPLE	NO. FAILING	% OF SAMPLE	NO
FRONT	BODY	7	.9	8	1.1	
BACK	BODY	17	2.3	16	2.2	
	HANGER	1	.1	1	.1	
FLAP	BODY	3	.4	3	.4	
	CORNER JUNCTION	5	.7	1	.1	
BOTTOM	BODY	1	.1			

COVERS, CANTEEN
SAMPLE SIZE: 737

2

TYPE II ANALYSIS

NUMBER OF COVERS WITH EACH TYPE OF FAILURE AT EACH LOCATION

TYPES OF FAILURES															
TCHING		FRAYS		FRAY TEARS		SEAM TEARS		SNAP FASTENER TEARS		WEAR AREAS		BENT			
NG	% OF SAMPLE	NO. FAILING	% OF SAMPLE	NO. FAILING	% OF SAMPLE	NO. FAILING	% OF SAMPLE	NO. FAILING	% OF SAMPLE	NO. FAILING	% OF SAMPLE	NO. FAILING	% OF SAMPLE	FAI
		5	.7					18	2.4	3	.4			
	1.2					3	.4							
	.3	7	.9	1	.1	10	1.4			33	4.5			
	11.7					17	2.3							
	20.1	35	4.7			229	31.1							
												5	.7	
	.4	2	.3					21	2.8					
		31	4.2	4	.5	15	2 0			2	.3			
		16	2.2							24	3.3			
	.4					3	.4							

TYPE II ANALYSIS

NUMBER OF CANTEEN COVERS WITH TEARS BY DIRECTION AND HOLES BY DEGREE

TYPES OF FAILURES							
ION OF TEARS				DEGREE OF HOLES			
VERTICAL		TWO-WAY		¼" OR LESS		¼" TO 1½"	
LING	% OF SAMPLE	NO. FAILING	% OF SAMPLE	NO. FAILING	% OF SAMPLE	NO. FAILING	% OF SAMPLE
	1.1	9	1.2	33	4.5	43	5.8
	2.2	18	2.4	71	9.6	150	20.4
	.1			3	.4	1	.1
	.4	1	.1	11	1.5	27	3.7
	.1			27	3.7	54	7.3
		2	.3	39	5.3	70	9.5

CANTEEN
ZE: 737

3

NALYSIS

E CF FAILURE AT EACH LOCATION

TYPES OF FAILURES												
RS	SEAM TEARS		SNAP FASTENER TEARS		WEAR AREAS		BENT		MISSING		BINDING TAPE FAILURES	
OF MPLE	NO. FAILING	% OF SAMPLE	NO. FAILING	% OF SAMPLE	NO. FAILING	% OF SAMPLE	NO. FAILING	% OF SAMPLE	NO. FAILING	% OF SAMPLE	NO. FAILING	% OF SAMPLE
			18	2.4	3	.4					15	2.1
									81	11.0		
	3	.4										
.1	10	1.4			33	4.5						
	17	2.3										
	229	31.1							11	1.5		
							5	.7	15	2.0		
			21	2.8							66	9.0
									18	2.4		
.5	15	2 0			2	.3					32	4.3
					24	3.3						
	3	.4										

E II ANALYSIS

TEARS BY DIRECTION AND HOLES BY DEGREE

PES OF FAILURES						
	DEGREE OF HOLES					
Y	¼" OR LESS		¼" TO 1½"		OVER 1½"	
% OF SAMPLE	NO. FAILING	% OF SAMPLE	NO. FAILING	% OF SAMPLE	NO. FAILING	% OF SAMPLE
1.2	33	4.5	43	5.8	8	1.1
2.4	71	9.6	150	20.4	15	2.0
	3	.4	1	.1		
.1	11	1.5	27	3.7	3	.4
	27	3.7	54	7.3	3	.4
.3	39	5.3	70	9.5	13	1.8

EXHIBIT M-2

1

COVERS, CANTEEN
SAMPLE SIZE: 737

TYPE III ANALYSIS

FREQUENCY OF TEARS BY DIRECTION AND HOLES

LOCATIONS OF FAILURES		TYPES OF FAILURES			
		DIRECTION OF TEARS			
		HORIZONTAL	VERTICAL	TWO-WAY	*
		NO. OF FAILURES	NO. OF FAILURES	NO. OF FAILURES	NO.
FRONT	BODY	11	15	6	
BACK	BODY	20	22	17	
	HANGER	1	1		
FLAP	BODY	6	7	1	
	CORNER JUNCTION	1	4		
BOTTOM	BODY	1		4	

TYPE III ANALYSIS

FREQUENCY OF EACH TYPE OF FAILURE AT EACH

LOCATIONS OF FAILURES		TYPES OF FAILURES						
		TEARS	HOLES	STITCHING	FRAYS	FRAY TEARS	SEAM TEARS	SNAP FASTENER TEARS
		NO. OF FAILURES	NO. OF FAILURES	NO. OF FAILURES	NO. OF FAILURES	NO. OF FAILURES	NO. OF FAILURES	NO. OF FAILURES
FRONT	BODY	32	139		6			19
	SNAP FASTENER (MALE)							
	STITCHING TO LINING			14			3	
BACK	BODY	59	381	2	11	2	10	
	SEAM (INCL. SIDE SEAM)			68			19	
	HANGER	2	4	191	51		313	
	HOOK							
FLAP	BODY	14	46	3	3			34
	SNAP FASTENER (FEMALE)							
	CORNER JUNCTION	5	80		35	5	16	
BOTTOM	BODY	5	162		18			
	SEAM			7			7	
FREQUENCY OF FAILURES BY TYPE OF FAILURE		117	812	285	124	7	368	53
PER CENT OF TOTAL FAILURES		5.5	37.9	13.3	5.8	0.3	17.3	2.5

COVERS, CANTEEN
SAMPLE SIZE: 737

2

TYPE III ANALYSIS
FREQUENCY OF TEARS BY DIRECTION AND HOLES BY DEGREE

TYPES OF FAILURES					
DIRECTION OF TEARS			DEGREE OF HOLES		
ZONTAL	VERTICAL	TWO-WAY	¼" OR LESS	¼" TO 1½"	OVER 1½"
F FAILURES	NO. OF FAILURES	NO. OF FAILURES	NO. OF FAILURES	NO. OF FAILURES	NO. OF FAILURES
11	15	6	54	74	11
20	22	17	130	227	24
1	1		3	1	
6	7	1	14	29	3
1	4		23	54	3
1		4	54	93	15

TYPE III ANALYSIS
FREQUENCY OF EACH TYPE OF FAILURE AT EACH LOCATION

TYPES OF FAILURES												
	HOLES	STITCHING	FRAYS	FRAY TEARS	SEAM TEARS	SNAP FASTENER TEARS	WEAR AREAS	BENT	MISSING	BINDING TAPE	TOTAL	
S	NO. OF FAILURES	NO. OF FAILURES	NO. OF FAILURES	NO. OF FAILURES	NO. OF FAILURES	NO. OF FAILURES	NO. OF FAILURES	NO. OF FAILURES	NO. OF FAILURES	NO. OF FAILURES	FREQUENCY OF FAILURES AT EACH LOCATION	% OF TOTAL FAILURES
	139		6			19	4			26	226	10.7
									91		91	4.3
		14			3						17	0.8
	381	2	11	2	10		43				508	23.7
		68			19						87	4.1
	4	191	51		313				11		572	26.8
								5	15		20	0.9
	46	3	3			34				98	198	9.2
									19		19	0.8
	80		35	5	16		3			32	176	8.2
	162		18				25				210	9.8
		7			7						14	.7
	812	285	124	7	368	53	75	5	136	156	2,138	
	37.9	13.3	5.8	0.3	17.3	2.5	3.5	0.2	6.4	7.3		100.0

EXHIBIT M-3

CARRIER, SH

SAMPLE

TYPE I ANALYSIS

NUMBER OF CARRIERS FAILING AT EACH LOCATION

LOCATIONS OF FAILURES	NUMBER FAILING	% OF SAMPLE
FLAP BODY	294	65.6
FRONT SNAP FASTENER (MALE)	101	22.5
OLD STYLE, TYPE II, DOUBLE HOOK	36 *	16.1 *
FRONT BODY	86	19.2
NEW STYLE, TYPE I, DOUBLE HOOK	31 *	13.8 *
FLAP BINDING TAPE	45	10.0
BACK BINDING TAPE	43	9.6
RIVETS	32	7.1
FLAP CENTER REINFORCEMENT	17	3.8
BACK BODY	11	2.5
FLAP SNAP FASTENER (FEMALE)	10	2.3
OLD STYLE, TYPE II, HANGER	4 *	1.8 *
NEW STYLE, TYPE I, EYELETS	3 *	1.3 *
FRONT SIDE REINFORCEMENT	6	1.3
NEW STYLE, TYPE I, EYELET STRIP	2 *	0.9 *
TOP REINFORCEMENT	3	0.7
FRONT CENTER STITCHING	1	0.2

* *Percentages based on number of old or new style samples and not on total sample.*

1

NUMBER OF CARRIERS WITH

LOCATIONS OF FAILURES		HOLES		TEARS		FRAYS		TEAR FRAYS		STITCHING		SEAM TEARS	
		NO. FAILING	% OF SAMPLE	NO. FAILING	% OF SAMPLE	NO. FAILING	% OF SAMPLE	NO. FAILING	% OF SAMPLE	NO. FAILING	% OF SAMPLE	NO. FAILING	% OF SAMPLE
FRONT	BODY	38	8.5	25	5.6					1	.2	1	.2
	SNAP FASTENER (MALE)												
	SIDE REINFORCEMENT					4	.9	2	.4				
	CENTER STITCHING									1	.2		
FLAP	BODY	224	50.0	29	6.5								
	SNAP FASTENER (FEMALE)												
	BINDING TAPE					2	.4	6	1.3	1	.2	12	2.7
	CENTER REINFORCEMENT	5	1.1	3	.7	1	.2			9	2.0	1	.2
BACK	BODY	8	1.9	2	.4							1	.2
	BINDING TAPE					1	.2	8	1.8	27	6.0	2	.4
	RIVETS												
NEW STYLE TYPE I	EYELET STRIP	1 *	.4	1 *	.4								
	EYELETS												
	DOUBLE HOOK												
OLD STYLE TYPE II	HANGER									3 *	1.3		
	DOUBLE HOOK												
	TOP REINFORCEMENT	3 *	.7									1 *	.2

* *Percentages based on number of o*

CARRIER, SHOVEL, INTRENCHING, M-1943
SAMPLE SIZE: OLD STYLE - 223
NEW STYLE - 225
TOTAL - 448

2

TYPE I ANALYSIS

NUMBER OF COVERS WITH EACH TYPE OF

TYPES OF FAILURES	NUMBER FAILING
HOLES	253
PARTS MISSING	116
PARTS BENT	65
TEARS	55
FLAP SNAP FASTENER TEAR (FEMALE)	52
STITCHING FAILURE	39
BINDING TAPE FAILURE	29
FRONT SNAP FASTENER TEAR (MALE)	27
SEAM TEARS	18
FRAY TEARS	16
FRAYS	8

TYPE II ANALYSIS

F CARRIERS WITH EACH TYPE OF FAILURE AT EACH LOCATION

TYPES OF FAILURES												DEGREES OF HOLES						DIRECT		
ITCHING		SEAM TEARS		MISSING		BENT		SNAP FASTENER TEARS		BINDING TAPE FAILURES		¼" OR LESS		¼" TO 1½"		OVER 1½"		HORIZONTAL		V
O. ING	% OF SAMPLE	NO. FAILING	% OF SAMPLE	NO. FAILING	% OF SAMPLE	NO. FAILING	% OF SAMPLE	NO. FAILING	% OF SAMPLE	NO. FAILING	% OF SAMPLE	NO. FAILING	% OF SAMPLE	NO. FAILING	% OF SAMPLE	NO. FAILING	% OF SAMPLE	NO. FAILING	% OF SAMPLE	NO. FAI
1	.2	1	.2					27	6.0			24	5.4	17	3.8	2	.4	16	3.6	
				101	22.5															
1	.2																			
								52	11.6			177	39.5	77	17.2	4	.9	15	3.3	
				10	2.2															
1	.2	12	2.7							26	5.8									
9	2.0	1	.2									1	.2	4	.9			3	.7	
		1	.2									7	1.6	1	.2			1	.2	
7	6.0	2	.4							5	1.1									
				32	7.1															
														1 *	.4					
				3 *	1.3															
				2 *	.9	29 *	12.9													
3 *	1.3			1 *	.4															
				1 *	.4	36 *	16.1													
		1 *	.2									1 *	.2	2 *	.4					

ages based on number of old or new style samples and not on total samples.

INTRENCHING, M-1943
OLD STYLE - 223
NEW STYLE - 225
TOTAL - 448

3

TYPE I ANALYSIS

NUMBER OF COVERS WITH EACH TYPE OF FAILURE

TYPES OF FAILURES	NUMBER FAILING	% OF SAMPLE
HOLES	253	56.5
PARTS MISSING	116	25.9
PARTS BENT	65	14.5
TEARS	55	12.3
FLAP SNAP FASTENER TEAR (FEMALE)	52	11.6
STITCHING FAILURE	39	8.7
BINDING TAPE FAILURE	29	6.5
FRONT SNAP FASTENER TEAR (MALE)	27	6.0
SEAM TEARS	18	4.0
FRAY TEARS	16	3.6
FRAYS	8	1.8

II ANALYSIS

TYPE OF FAILURE AT EACH LOCATION

TYPES OF FAILURES																			
								DEGREES OF HOLES						DIRECTIONS OF TEARS					
SSING		BENT		SNAP FASTENER TEARS		BINDING TAPE FAILURES		¼" OR LESS		¼" TO 1½"		OVER 1½"		HORIZONTAL		VERTICAL		TWO-WAY	
G	% OF SAMPLE	NO. FAILING	% OF SAMPLE	NO. FAILING	% OF SAMPLE	NO. FAILING	% OF SAMPLE	NO. FAILING	% OF SAMPLE	NO. FAILING	% OF SAMPLE	NO. FAILING	% OF SAMPLE	NO. FAILING	% OF SAMPLE	NO. FAILING	% OF SAMPLE	NO. FAILING	% OF SAMPLE
				27	6.0			24	5.4	17	3.8	2	.4	16	3.6	6	1.3	4	.9
	22.5																		
				52	11.6			177	39.5	77	17.2	4	.9	15	3.3	5	1.1	9	2.0
	2.2																		
						26	5.8												
								1	.2	4	.9			3	.7				
								7	1.6	1	.2			1	.2	1	.2		
						5	1.1												
	7.1																		
										1 *	.4					1 *	.4		
*	1.3																		
*	.9	29 *	12.9																
*	.4																		
*	.4	36 *	16.1																
								1 *	.2	2 *	.4								

new style samples and not on total samples.

Appendix B EXHIBIT P-1

1

CARRIER, SHOVEL, INTRENCHING, M-1943
SAMPLE SIZE: OLD STYLE - 223
NEW STYLE - 225
TOTAL - 448

TYPE III ANALYSIS

FREQUENCY OF EACH TYPE OF FAILURE AT EACH LOC

LOCATIONS OF FAILURES		TYPES OF FAILURES										
		HOLES	TEARS	FRAYS	TEAR FRAYS	STITCHING	SEAM TEARS	MISSING	BENT	SNAP FAST-ENER TEARS	BIND-ING TAPE FAIL-URES	FRE QUEN OF FA URES EAC LOC TI
		NO. OF FAIL.	NO. OF FAIL.	NO. OF FAIL.	NO. OF FAIL.	NO. OF FAIL.	NO. OF FAIL.	NO. OF FAIL.	NO. OF FAIL.	NO. OF FAIL.	NO. OF FAIL.	
FRONT	BODY	61	31			1	1			28		12
	SNAP FASTENER (MALE)							101				10
	SIDE REINFORCEMENT			5	2							
	CENTER STITCHING					1						
FLAP	BODY	357	37							52		44
	SNAP FASTENER (FEMALE)							10				1
	BINDING TAPE			12	6	1	13				28	6
	CENTER REINFORCEMENT	11	3	1		9	2					2
BACK	BODY	9	3				1					1
	BINDING TAPE			1	8	28	4				5	4
	RIVETS							48				4
NEW STYLE TYPE I	EYELET STRIP	1	1									
	EYELETS							4				[illegible]
	DOUBLE HOOK							2	31			3
OLD STYLE TYPE II	HANGER					3		1				[illegible]
	DOUBLE HOOK							1	37			3
TOP REINFORCEMENT		3					1					[illegible]
FREQUENCY OF FAILURES BY TYPE OF FAILURE		442	75	19	16	43	22	167	68	80	33	965
PER CENT OF TOTAL FAILURES		45.7	7.7	2.0	1.7	4.5	2.3	17.3	7.1	8.3	3.4	

CARRIER, SHOVEL, INTRENCHING, M-1943
SAMPLE SIZE: OLD STYLE - 223
NEW STYLE - 225
TOTAL - 448

2

TYPE III ANALYSIS

FREQUENCY OF EACH TYPE OF FAILURE AT EACH LOCATION

TYPES OF FAILURES												DEGREES OF HOLES			DIRECTIONS OF TEARS		
OLES	TEARS	FRAYS	TEAR FRAYS	STITCH ING	SEAM TEARS	MISSING	BENT	SNAP FASTENER TEARS	BINDING TAPE FAILURES	FREQUENCY OF FAILURES AT EACH LOCATION	% OF TOTAL FAILURES	¼" OR LESS	¼" TO 1½"	OVER 1½"	HORIZONTAL	VERTICAL	TWO-WAY
. OF AIL.	NO. OF FAIL.	NO. OF FAIL.	NO. OF FAIL.	NO. OF FAIL.	NO. OF FAIL.	NO. OF FAIL.	NO. OF FAIL.	NO. OF FAIL.	NO. OF FAIL.			NO. OF FAIL.	NO. OF FAIL.	NO. OF FAIL.	NO. OF FAIL.	NO. OF FAIL.	NO. OF FAIL.
61	31			1	1			28		122	12.6	35	24	2	17	10	4
						101				101	10.5						
		5	2							7	.7						
				1						1	.1						
357	37							52		446	46.2	259	94	4	16	9	12
						10				10	1.0						
		12	6	1	13				28	60	6.2						
11	3	1		9	2					26	2.8	6	5		3		
9	3				1					13	1.3	6	3		1	2	
		1	8	28	4				5	46	4.8						
						48				48	5.1						
1	1									2	.2		1			1	
						4				4	.4						
						2	31			33	3.4						
				3		1				4	.4						
						1	37			38	3.9						
3					1					4	.4	1	2				
442	75	19	16	43	22	167	68	80	33	965							
45.7	7.7	2.0	1.7	4.5	2.3	17.3	7.1	8.3	3.4		100.0						

Appendix B

EXHIBIT P-2

APPENDIX E

COMBAT BOOT FAILURES

Report of Observations and Studies
on Salvaged Boots from Korea

Fort Lee, Virginia

June 12-15, 1952

United Shoe Machinery Corporation
Boston, Massachusetts

Observers

J. P. Fredericksen
F. N. Lee

M. Maeser
E. L. Poulin

CONTENTS

INTRODUCTION

Five-thousand pairs of salvaged boots, worn in Korea, were returned to Fort Lee, Virginia, for study and tabulation of failures.

In October 1951, Mr. E. L. Poulin of the United Shoe Machinery Corporation, at the request of the Research and Development Division of The Quartermaster General's Office, went to Fort Lee to assist in making a preliminary examination of the boots and formulating a check sheet against which failures could be tabulated.

As this preliminary examination progressed, it was seen that here, in large numbers, were boots with nearly every possible type of shoe part failure in varying degrees of development. The situation seemed excellent for making a study of the probable causes of the various failures which were found. There were, for instance, enough boots with heels of varying degrees of looseness so that the progress of heel fastening failures could be studied. A study could also be made of the related effects of such items as nail length, corrosion, and strength, variations in the thickness of the heel seat due to materials and lasting, and variations in heel washer location and nailing pattern. The same situation existed in regard to sole failures, insole failures, and other types of failure.

The situation was discussed with Mr. Walkey and a suggestion was made that Mr. Poulin select from the personnel of the United Shoe Machinery Corp. a group of men, with the necessary experience, to make a study of the causes and relations of the various failures found in the boots. Three men, in addition to Mr. Poulin, were selected. The group visited Fort Lee and studied the failures in 700 of the 5000 pairs of salvaged boots.

The observations and analyses made during this examination and the results of tests made previously at the United Shoe Machinery Corporation were correlated and widely discussed before drawing the conclusions contained in this report.

This report does not include any specific recommendations because --

1. Further research and testing will be required to produce satisfactory solutions to the problems which were found. These solutions might indicate changes in manufacturing procedures, materials, and machinery, but in what direction or to what extent is not now known.

2. This study is only part of a broad study and analysis of the failures in a large number of salvaged boots. The results of other parts of the study will be given in --

(1) Report of OQMG failure tabulation.
(2) Report of OQMG personnel observations.
(3) Report of observations by the industry committee.
(4) Reports of any other observations which might be made.

Any recommendations for new research and testing, changes in shoe manufacturing procedures or changes in shoe materials should be based on the observations and findings in all the above reports.

SUMMARY OF OBSERVATIONS

1. Shoe Part Failures

During the course of the inspection failures of many types were observed.

Four of these seriously affect the service life of the boots and occur with enough frequency to justify changes in either materials, construction, or shoemaking practice. These, listed below in order of their importance, are:

A. Insole failures
B. Heel Fastening Failures
C. Sole Fastening Failures
D. Quarter Closing Seam Failures.

Many minor failures which could be attributed to some special cause were found. Among the causes of such failures are:

A. Special work performed by the wearer.
B. Special walking habit or foot condition of the wearer.
C. Exposure of the boots to heat when wet.
D. Occasional faulty shoemaking.

2. Satisfactory Parts and Materials

The following shoe parts and materials appeared to be satisfactory from the standpoint of service.

A. Heel materials
B. Outsole material. (Except that the rubber has a tendency to stretch in wear)
C. Midsole material
D. Welt material'
E. Upper material especially when used with the grain out
F. Counter material
G. Insole reinforcing material
H. Inseam - construction and thread.

3. Comparison of Failures in Old and New Type Boots

There were only 64 pairs of the new type boots among the 1000 pairs separated for this study. This constituted a small sample. In general, the new boots had received less wear and apparently had undergone less severe service than the old boots. For these reasons, a fair comparison between the old and new type boots could not be made. Among the new boots there were heels with different amounts of wear and different degrees of looseness on the shoe. A study of the fastenings of these heels indicated that the same types of failure were developing in the new as were found in the old type boots.

Note: Of interest is the comment by Mr. J. P. Fredericksen who, in 1943, inspected a large number of military footwear, before the boots were rebuilt, at the Bluff City Shoe Reconstruction Factory, Hannibal, Missouri "One of the things that was outstanding and quite noticeable was that the condition of the insole heel seats in the Fort Lee boots was greatly improved compared with shoes check in May of 1943 at Hannibal. The improvement can, no doubt, be attributed to the use of fibre pegging for heel seat fastening and the use of brass heel seat tacks and heel nails."

GENERAL INFORMATION

Dates on Which the Boots were Examined

May 12, 13, 14, 15, 1952

United Shoe Machinery Corporation Personnel Involved:

Mr. J.P. Fredericksen, Goodyear Department, Boston
Mr. F.N. Lee, Research Division, Beverly
Mr. M. Maeser, Research Division, Beverly
Mr. E.L. Poulin, Research Division, Boston

Setup for Inspection;

In preparation for this study, the personnel at Fort Lee had segregated the first 1000 pairs of boots on which the failures had been tabulated into six categories as follows:

1. All boots of latest type (full laced boots)
2. Sole component failures only (cuff boots)
3. Upper component failures only (cuff boots)
4. Upper and sole component failures (cuff boots)
5. Repaired or rebuilt boots
6. No visible failures other than general wear (cuff boots)

Note: Pairs as referred to in this report mean one right and one left shoe and not mated pairs as issued and worn.

Number of Boots Inspected:

Approximately 700 pairs of boots were inspected by the writers. The number taken from each of the categories noted above was:

Category	Pairs in Category	Pairs Inspected
#1	64 pairs	64 pairs
#2	64 pairs	64 pairs
#3	192 pairs	96 pairs
#4	384 pairs	384 pairs
#5	48 pairs	None
#6	224 pairs	192 pairs

Note: Boots were packed in wooden boxes containing an average of 16 pairs to the box. The above figures are based on the number of boxes examined.

General Procedure:

The observers worked in two teams. Messrs. Lee and Maeser devoted their full attention to heel end failures. The procedure which they followed and the results of their observations are given in DETAILS OF OBSERVATIONS, Part B pg. 6 of this report.

Messrs. Fredericksen and Poulin studied all other failures which were found in the 700 pairs of boots inspected. Their procedures and observations are given in DETAILS OF OBSERVATIONS, Part A - pgs. 4-5-6 and Part C - pgs. 6-7-8-9 of this report.

Fort Lee personnel assisted by handling boxes of boots, pulling off heels and cutting away uppers.

DETAILS OF OBSERVATIONS

With comments and suggested ways of reducing failures.

A. Insole Failures

The major insole failures were of three types:

1. Cracked or Broken Insoles

All insoles, except those in boots that were new or only slightly worn, were discolored, hard and brittle and had cracks which varied from

surface checking to a complete break through the insole. Boots with badly cracked insoles usually had associated outsole fastening failures. Extra stress put on the outsole fastening when the insole ceased to function properly could account for such failures.

Insole cracking seems to be related to the progressive deterioration and embrittlement of the leather due to repeated wetting and drying.

2. Shrunk and Distorted Insoles

All insoles in boots which had been worn for a considerable length of time showed signs of shrinkage and distortion.

When insoles become wet, either from perspiration or water, the leather becomes soft and the insoles are easily distorted by the weight on the feet and the forces of walking. In well fitted boots the insoles were shaped to the bottom of the foot and dished downward between the ribs. In poorly fitted boots extreme cases of insole bulging, warping, dishing and guttering developed.

When insoles dry out, they shrink. The distance between the inseams tends to decrease but is restrained from doing so on the flesh side by the attachment of the insole rib to the outsole through the welt. The grain side and the feather area outside the rib, being free to shrink, pull toward the center of the insole. The anchored insole rib acts as a pivot about which the stresses resulting from the shrinkage of the grain and the insole distortion combine to cause the insole edge to curl toward the foot. Insoles were found on which the channeling margin was wider than necessary resulting in extreme edge curling.

Insole shrinkage and distortion failures result, at least in part, from the effects of repeated wetting and drying.

3. Insole Rib Failures

In all rib failures which were found, the in-between substance had been torn away from the body of the insole. This type of failure was always associated with the deterioration of the cement bond between the Gem Duck insole reinforcing and the insole. The inseam was generally intact and was held in place by the Gem Duck.

These failures result from any combination of the following conditions:

a. The use of poor insole leather.
b. Poor insole making.
c. Strains due to insole shrinkage.

d. Deterioration of the leather in the rib.
e. Weakening of the rib by excessive pounding to flatten the lasting allowance overlay.

B. Correction of Insole Failures

All the above failures could be reduced in frequency if insoles were made of a material which was not deteriorated or shrunk by repeated wetting and drying. Chrome retanned insoles are now specified in all new army boots. It is hoped that this change will reduce insole deterioration and associated failures.

Care in making the insole, so that channel depth, inbetween substance, width of margin, and other insole making factors are correct for the particular material and application used, would result in fewer insole failures.

(The elimination of the pounding operation necessary to flatten the overlay should be considered)

C. Heel Fastening Failures

1. Procedure

In order to get a broad picture of the various factors which might contribute to the failure of the heel fastenings, a large number of heels were pulled from boots, and the condition of the nails in each heel was studied.

The heel fastening on boots with tight heels and loose heels, and the heel seats on some boots with the heels missing were examined.

Some boots were selected from a particular group because the heels were loose or badly worn as compared with the average of the group. In other cases, shoes were taken at random as they came out of the boxes.

Heels were pulled from a number of shoes, taken from each of the segregated groups noted on page 3 except from group No. 5, "Repaired or Rebuilt Boots."

The boots were examined visually, and the condition of the insole and the tightness of the heel fastening was observed and recorded before the heel was pulled off.

To remove the heel from the boot, a chisel-pointed bar was pushed between the heel and the outsole at the center of the breast and the bar was pushed away from the shoe bottom. This pried the breast of the heel

from the boot. The back of the heel was then worked loose. Pulling the heels in this manner caused a large number of nails to be broken. Most commonly, the nails were simply pulled apart near the tip with part of the nail remaining in the heel seat. When the back of the heel was hard to loosen, the three nails near the back were often bent badly and sometimes broken. A few heel seats were torn apart and the broken nails were removed to see if the points were clinched. There were more unclinched than clinched tips found.

After the heel was removed, the nails were studied and tabulated as to the number which were "Buckled," "Clinched" and "Unclinched". Nails which were broken in pulling off the heel could not be safely classified as either clinched or unclinched. These nails were tabulated separately as nails with "Tips Pulled Off."

Many nails showed old breaks at a level corresponding to the interface of the midsole and outsole. When nails were missing from the heels, the heel seat was examined to determine whether or not the nail had broken at this interface with part of the nail remaining in the heel seat. In general, this was found to be true. Nails broken at this interface were always corroded to some extent. Examination of the broken section often revealed the type of fracture which is characteristic of fatigue. The broken ends were often so badly corroded, or mutilated, from the two parts of the broken nails rubbing against each other, that study of the break was not possible. Such failures were tabulated as "Breaks at M & O Interface," which means breaks at the midsole-outsole interface.

A few nails either pulled through the washers when the heel was pulled off or were driven through the washer in heeling. In a few cases the washers were pulled out of the heel when the heel was pulled off. These nails are listed in separate columns.

2. Tabulation of Observations

The results of the above observations are given in Tables Nos. I to X, Appendix.

3. Results

The tabulated data and the observations made indicate the following results:

a. Buckling -

The number of buckled nails was very small, indicating that #1336 brass nails are strong enough to be driven through the heel seat materials.

b. Clinching -

(1) An average of only four to five nails per heel were clinched. This number would be increased if the nails with the tips pulled off could be properly split up into clinched and unclinched nails.

(2) The number of unclinched nails was greater than the number of clinched nails.

(3) Some heels were pulled off that had no nails clinched.

c. Dezincing of Nails.

Nails which were broken near the tips when the heel was pulled off almost invariably showed a porous, bright-red, broken section. This showed that the zinc in the brass had been almost totally removed by chemical action, leaving the nails weak and brittle. Such nails could be bent no more than five to ten degrees without rupture. (Note: New nails can be bent near the tips 150° to 180° without breaking.) Many nails which showed old breaks at the midsole-outsole interface were broken by hand near the old break. These nails generally showed dezincing, ranging from a thin red skin to almost complete extraction of the zinc.

d. Fatigue of Nails.

When heels were badly worn or had become loose on the shoe or when the heels were missing from the shoe, there was a greater than average number of nails broken at the midsole-outsole interface. In loose heels, i.e., heels which could be moved relative to the shoe by hand, from four to eleven nails showed this type of failure. When the heel was missing from the boot, the heel seat was torn apart and those nail tips remaining in the leather were collected. In over one-half such shoes, all the nails were still in the heel seat, broken at the midsole-outsole interface.

The nature of the lines on the broken section of the nail and the fact that such breaks were always just under the outer surface of the midsole leads to the conclusion that these nails were broken by being repeatedly bent first one way then another. The mechanism of this failure seems to be about as follows:

When the nails are driven, 3/8" or more of the nail is securely anchored in the stiff, firm leather of the insole, lasted in upper and counter, and midsole. This leaves approximately 5/8" of the nail in the soft rubber of the outsole and heel. The heads of the nails rest in the cups of the washers. The washers float in the rubber of

the heel. When the shoe is subjected to rough water, the heel is pushed first one way then another. The soft rubber allows the heel to float from side to side, and the nail heads are carried with it. The nails are thus subjected to bending at their fixed support, which is the interface of the midsole and the outsole. If wear continues the nails will eventually fatigue and break at this point.

Failures of this type were produced in tests, made in 1944, in which heels were subjected to repeated forces of 150 lbs. first one way then another. The tests showed that new, i.e. uncorroded brass nails held up slightly better than new zinc-plated steel nails of the same size when the heels were subjected to this type of action. The effects of corrosion were not studied in these tests, but it seems safe to assume that either the rusting of steel nails or the dezincing of brass nails would shorten the life of nails under such conditions.

D. Possible Solutions to the Problem of Heel Fastening Failures.

This study indicates that the two major causes of heel fastening failures are:

1. Lack of Nail Clinching and Resultant Weak Fastening of the Heel to the Boot

Poor nail clinching is a result of a combination of materials and lasting variations which allow the total thickness of the material substance between the nail washers in the heel and the inner surface of the insole to exceed 1/16" less than the length of the nail. These variations, which may occur in any combination, include:

a. Too liberal tolerances in the thickness of the outsole, midsole, upper leather, counter and insole. If the maximum allowable thickness of all these materials is used simultaneously, the heel seat becomes so thick that $9\frac{1}{2}/8$ nails will not go through to the heel plate; and yet, if the minimum allowable thickness of all materials were used, the nail would have excessive clinch. As long as variables are present in the shoe parts, the possibility of some or all of the nails being unclinched still exists. This problem has been recognized for some time but none of the suggested approaches to a solution appear to be practicable.

b. Lasting variations which affect the thickness of the heel seat such as -

(1) Insole rib upstanding back of score lines.
(2) Improper breast line lasting.
(3) Welt sewed too high at butt.

(4) Counter flange too high on one side.
(5) Improperly bedded lasting allowance.

c. Lack of standardization of the heel as to size, overall thickness, thickness between washers and base, nail pattern, and scheduling.

Note: The relocation of 5 rear washers in the rubber heels, now in process, will eliminate one variable in the substance of the heel and should result in some increase in the number of clinched nails.

2. Nail Breakage.

Improvement in nail breakage could be obtained by:

a. Making nails of a material which will not corrode. This would eliminate the weakening of the nails by rusting, as in steel nails, or dezincification, as in brass nails, and would stop deterioration of the heel seat such as develops when steel nails and moist vegetable tanned sole leather come in contact with each other at the surface of the insole.

b. Stiffening the heel end of the outsole. If that portion of the outsole which extends under the heel were made as hard or harder than a piece of vegetable tanned sole leather, the amount of soft rubber and the length of the heel nail between the nail washers and a firm base would be decreased from approximately 5/8" to 5/16" resulting in a stiffer and more stable heel end and increased life of the heel fastening.

c. Stiffening of the heel.

If the heel as a whole, but more particularly that part between the washers and base, were compounded of harder material or reinforced to make it stiffer, some improved heel fastening life might be obtained. If both the heel end of the outsole and that portion of the heel between the washers and the base were made stiffer, a marked improvement in heel fastening life should be obtained. The tendency for the heel to float relative to the heel seat would be reduced to a point where nail breakage due to this type of action should be one of the rare causes of heel fastening failure.

Consideration should be given to stiffening the base portion of the heel with a construction such that the heel would have sufficient holding power against the nail head without the use of washers. Such heels would -

(1) Permit standardization of a nailing pattern consistent with the size of the insole heel seat.

(2) Eliminate variations in the nailing pattern.

(3) Eliminate the need for angular nail drive.

If these changes were made, there would be greater assurance that the nail points would pass through the insole.

d. Reducing the thickness of the outsole under the heel.

Some shoe men consider the present heel on Army Combat boots approximately 1/8" too high for proper tread. If the heel end of the outsole were reduced by this amount, some improvement in nail life would be expected. If an outsole with a thinner and stiffer heel end were used with a heel which was stiffer between the washers and the base, the heel fastenings should have greater average life than at present.

E. Sole Fastening Failures.

The three means used in combat boots to fasten the sole components on the shoe are; (1) the cement bond between the outsole and the midsole, (2) the Goodyear stitching through the outsole, midsole and welt, and (3) the reinforcing nails through the outsole, midsole and insole. Failure of these fastenings results in separation of the outsole from the midsole or the midsole from the welt, or both.

The majority of these failures occurred between the outsole and midsole. In most cases where the midsole had separated from the welt, the outsole and midsole had also separated, and there were indications that the outsole midsole separation occurred first. In a few boots failures occurred only between the midsole and welt.

1. Cement Bond Failures.

In all boots where the outsole and midsole had separated the cement bond had partially or entirely deteriorated. This deterioration may have resulted from any of the following causes:

a. Inadequate cement life.
b. Poor roughing.
c. Lack of complete contact between midsole and outsole at assembly.
d. Weak bond to midsole because of oil in leather.
e. Lack of compatability between cement and rubber.

2. Goodyear Stitching Failures.

Goodyear stitching failures were caused by either lack of thread lock peg holding power or shearing of the threads.

a. Thread Lock Failures -

In most boots the thread lock was properly placed. On such boots, when the thread bar between stitched on the shoe bottom was worn off, there was insufficient peg holding power in the outsole to keep it in place. Boots were examined in which thread ends, with lengths equal to the outsole thickness, were found lying loose between the midsole and outsole. There were a few boots in which the thread lock was placed too deep in the outsole with the result that the peg holding strength was extremely low.

b. Thread Shear Failures.

There were boots in which the thread seam had sheared between the outsole and midsole or between the midsole and the welt. When the seam sheared between the outsole and midsole, these parts could separate. This type of failure left the threads in the midsole with neither a thread bar nor a lock peg, and the midsole was free to slip on the threads and separate from the welt.

Examination of thread failures on 56 boots taken from Category 4 shoed 32 with the thread sheared and 24 with thread lock failures. Only 6 of the boots with thread lock failures had the lock placed too deep.

3. <u>Reinforcing Nail Failures.</u>

Three types of reinforcing nail failures were found:

a. Boots were examined in which the nails had corroded in the insole until they were too weak to resist the stress of wear. The corrosion was due, chiefly, to the loss of zinc in the brass.

b. In other boots some of the nails were lost. This could be caused by either the nail tip corroding off so that the nail pulled out easily, or the nail being loosened in the insole by the relative movement of the bottom units as the boot was flexed.

c. Reinforcing nails were found which were broken at the midsole-outsole interface. Such nails were probably broken by fatigue in the same manner as the heel nails as described under "Fatigue of Nails", page 8.

4. <u>Interrelation of Sole Fastening Failures.</u>

Failure of the cement bond affected the other attaching means in two ways:

a. When boots were flexed in walking, the outsole tends to move

relative to the midsole and high shearing forces are developed between the two. If the cement bond is broken, the full shearing action is transferred to the thread seam and the reinforcing nails.

b. When boots are worn, the rubber outsoles tend to expand. This tendency is restrained by the attachment of the outsole to the midsole. If the cement bond fails, the full force of this restraint falls on the thread seam and reinforcing nails.

F. Correction of Sole Fastening Failures.

Sole fastening failures would probably be materially reduced by the use of:

1. The best possible thread.
2. The best combination of machine and bobbin thread to provide the best peg and lock strength possible.
3. The smallest possible needle and awl permissible with the size of thread.
4. Extra care in placing the thread lock.
5. A reinforcing nail which would not corrode.
6. A cement which will give a strong permanent bond between the sole units. A cement, equal in quality to a good grade of permanent sole attaching cement, is indicated.

G. Quarter Closing Seam Failures.

A very high percentage of the boots examined had quarter closing seam failures which varied from 1/2" to 2" in length. Nearly all the breaks, that were small when examined, were located just above the counter, the point at which the upper is most severely flexed, indicating that these failures started here. Examination of these early failures indicated that the seam threads had been abraded by rubbing against the wearer's socks. As a boot with early failure was continued in service, the break enlarged both ways from the starting point. The threads in the seam progressively abraded or loosened.

H. Correction of Closing Seam Failures.

Two means of correcting this type of failure should be considered:

1. The use of a thread with greater abrasion resistance. Some synthetic thread or a treated thread may be better for this application.

2. A change in construction to give this seam greater protection.

I. Other Failures.

1. Upper Failures

Most of the failures which were found in the upper leather appeared to be caused by some particular abuse to which the shoe was subjected.

In several boots the upper leather was worn through just above the welt. It appeared to have been severely abraded against the turned up and embrittled edge of the insole. In other boots the leather was abraded on the outside where it appeared to have been rubbed repeatedly against some metal part of a gun, tank or machine.

The upper leather appeared to be satisfactory from the standpoint of wear for the great majority of the boots.

2. Upper Seam Failures

Serious upper seam failures seldom appeared except in boots which had other more serious failures. There were a few boots in which the upper seams were abraded by repeated rubbing against some object such as a machine or gun part.

3. Chipped Sole Edges

In some boots a section of the outsole had broken away from the Goodyear stitch line to the edge. This condition could be caused by walking or crawling over rough terrain. Chipped edges appeared more often in boots with the stitching too close to the edge of the sole than in boots with normally placed seams.

This trouble might be reduced if:

a. The seams were placed properly at stitching, and
b. The edges were trimmed in proper relation to the stitch line and not undercut.

4. Burned Sole Edges

Many boots were found in which the midsole and welt edges had been "burned" as a result of placing a wet boot too close to a source of heat.

This can be helped by:

a. Training the wearer to keep wet shoes away from heat.

b. Using a midsole and welt material which will not absorb water and is resistant to heat.

5. Counter Failures

Only a few boots were found in which the heel ends were broken down or distorted due to counter failures.

Such failures as were found appeared to be the result of some peculiar foot condition or walking habit of the wearer.

6. Bottom Filler

A few boots were examined in which the bottom filler was badly distorted. This condition generally appeared to be caused by either improper fitting or excessive distortion of the insole.

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OLD BOOTS SHOWING BOTTOM FAILURES ONLY

TABLE I

22 Boots Tested

Tightness of Heel	Insole	Buckled Nails	Known Clinched Nails	Known Unclinched Nails	Tips Pulled Off	Breaks at M & O Interface	Pulled out of Washers	Pulled Washers
Tight	new	0	1	12				
"	good	0	13					
"	"	0		1	12			
"	"	0	12	1				
"	"	1	6	1	6			
"	"	2	9	4				
"	"	0	7	6				
"	"	0	4	3		6		
"	"	0	11	2				
"	"	0	12	1				
"	"	0		1	12			
"	"	1	3	3	7			
"	"	2	6	7				
"	"	0	5		5		3	
"	"	0	7	6				
"	"	0	8	2	3			
"	"	0	0	3	10			
"	"	1	5	2	5		1	
"	"	1	4	7	2			
"	fair	1	3	10				
"	"	2	3	9		1		
"	check	0		7	6			
TOTAL OF EACH FAILURE:		11	119	88	68	7	4	
AVERAGE OF EACH TYPE OF FAILURE:	Nails/Shoe:	.5	5.41	4.00	3.1	.32	.18	

OLD BOOTS SHOWING BOTTOM FAILURES ONLY

TABLE II

32 Boots Tested

Tightness of Heel	Insole	Buckled Nails	Known Clinched Nails	Known Unclinched Nails	Tips Pulled Off	Breaks at M & O Interface	Pulled out of Washers	Pulled Washers
Crack*	good	2	4	9				
"	"	0	12		1			
"	"	0	11	1	1			
"	"	0	2	9	1		1	
"	"	1	10	2		1		
"	"	1			13			
"	"	1	7		6			
"	"	0	0	13				
"	"	2	7	5		1		
"	"	0	6	7				
"	"	1	2		9	2		
"	"	1	4	5	4			
"	"	0	2	7		4		
"	"	0	7	1	5			
"	"	0	10		2		1	
"	"	1	6	4	3			
"	"	0	5	1	3			
"	"	0	0	8	3			
"	"	0	6	2	2			
"	"	2	8	3	3			
"	"	0		10	6			
"	"	0		10	3			
"	"	0	9	1	2			
"	"	0	0	11		2		
"	"	2	4	6		1		
"	"	1	3	4		2		
"	"	0	4	6		1		

OLD BOOTS SHOWING BOTTOM FAILURES ONLY

TABLE II (CONT)

32 Boots Tested

Tightness of Heel	Insole	Buckled Nails	Known Clinched Nails	Known Unclinched Nails	Tips Pulled Off	Breaks at M & O Interface	Pulled out of Washers	Pulled Washers
Crack*	good	0	5	3				
"	fair	3	2	9				
"	"	2	4	8				
"	"	0	4	7				
"	crack	1	5	7				
TOTAL OF EACH FAILURE:		21	149	159	84	14	2	
AVERAGE OF EACH TYPE OF FAILURES: Nails/Shoe:		.66	4.66	4.97	2.63	.40	.06	

* Slight opening at the breast between heel and midsole

OLD BOOTS SHOWING BOTTOM FAILURES ONLY

TABLE III

31 Boots Tested

Tightness of Heel	Insole	Buckled Nails	Known Clinched Nails	Known Unclinched Nails	Tips Pulled Off	Breaks at M & O Interface	Pulled out of Washers	Pulled Washers
Loose*	good	0		6			7	
"	"	0	8	5				
"	"	0	7	3		2		1
"	"	2	2	10		1		
"	"	0	0	2		11		
"	"	0	0	5		8		
"	"	0	0	13				
"	"	3	4	9				
"	"	0	4	9				
"	"	0	3	10				
"	"	0	6	1	6	3		
"	"	0	2	8		11		
"	"	0	0	2		1		
"	"	0	0	11	1			
"	"	0	1	8	4			
"	"	0	4	8		1		
"	"	0	4	2	7			
"	"	0	2	5	6			
"	"	0	6	4	3			
"	"	0	0	1	12			
"	"	0	3	7	2	1		
"	fair	1	3	6		3	1	
"	"	0	5	4	4			
"	"	1	1	12				
"	"	0	2	8		3		
"	"	2	3	8		2		
"	check	0	0	12				

OLD BOOTS SHOWING BOTTOM FAILURES ONLY

TABLE III (CONT.)

31 Boots Tested

Tightness of Heel	Insole	Buckled Nails	Known Clinched Nails	Known Unclinched Nails	Tips Pulled Off	Breaks at M & O Interface	Pulled out of Washers	Pulled Washers
Loose*	check	0	1	6		6		1
"	crack	1	6	7				
"	"	1	2	7		4		
"	"	0	1	4		8		
TOTAL OF EACH FAILURE:		11	80	203	45	65	8	2
AVERAGE OF EACH TYPE OF FAILURE: Nails/Shoe:		.35	2.58	6.55	1.50	2.10	.26	.06

* Some portion of these heels such as a corner or the breast could be moved relative to the outsole by hand.

OLD BOOTS SHOWING BOTTOM FAILURES ONLY

TABLE IV

6 Boots Tested

Shoes with Heels Off --	Two nails broken at midsole-outsole interface -- 11 nails lost.
	All nails lost.
	All nails lost - nearly new.
	All nails lost - nearly new.
	All nails broken at interface, midsole-outsole.
	All nails broken at interface, midsole-outsole.

OLD BOOTS SHOWING UPPER & LOWER FAILURES

TABLE V

35 Boots Tested

Tightness of Heel	Insole	Buckled Nails	Known Clinched Nails	Known Unclinched Nails	Tips Pulled Off	Breaks at M & O Interface	Pulled out of Washers	Pulled Washers
Loose*	good	0	0	11	2			
"	"	0	4	1	3	5		
"	"	0	2	7	3		1	
"	"	0	0	6	6	1		
"	"	1	3	8		2		
"	"	1	2	7	3	1		
"	"	0	4	9				
"	"	0	3	2	5	1	1	1
"	"	0	1	5	3	4		
"	"	0	1	3		9		
"	"	0	3	8	2			
"	fair	0	0	6	2	4	1	
"	check	0	0	13				
"	"	1	5	5		3		
"	"	0			5	8		
"	"	1	2	7	3	1		
"	"	0	0	6		7		
"	"	0	0	3		10		
"	"	0	0	1	4	8		
"	"	0	3	5	3	2		
"	"	0	4	3	2	4		
"	"	0	0	4	4	5		
"	"	0	0	6		7		
"	"	0	1	3		5		
"	crack	0	1	4		8		
"	"	0	2	9			2	
"	"	0	0	6	4	3		
"	"	1	3	6			4	

OLD BOOTS SHOWING UPPER & LOWER FAILURES

TABLE V (CONT.)

35 Boots Tested

Tightness of Heel	Insole	Buckled Nails	Known Clinched Nails	Known Unclinched Nails	Tips Pulled Off	Breaks at M & O Interface	Pulled out of Washers	Pulled Washers
Loose*	crack	0	5	3	3	2		
"	"	0	0	10			3	
"	bad	0	0	2	3	8		
"	"	0	1	2		10		
"	"	1	5	5		2	1	
"	wrinkle	0	7	4		1	1	
		0	3	8	2			
		6	65	188	62	121	14	1

OLD BOOTS SHOWING UPPER & LOWER FAILURES

TABLE VI

4 Boots Tested

Shoes with Heels Off --	Thirteen Nails broken at midsole-outsole interface.
	Thirteen Nails broken at midsole-outsole interface.
	Thirteen Nails broken at midsole-outsole interface.
	Nine Nails broken at midsole-outsole interface - four lost.
TOTALS:	39 Nails broken at midsole-outsole interface.
	4 Nails lost.

TABLE VII

NEW BOOTS SHOWING UPPER & LOWER FAILURES
Selected for Bad Heels
11 Boots Tested

Tightness of Heel	Insole	Buckled Nails	Known Clinched Nails	Known Unclinched Nails	Tips Pulled Off	Breaks at M & O Interface	Pulled out of Washers	Pulled Washers
Loose*	good	0	5	7		1		
"	"	0	2	11				
"	"	0	1	12				
"	"	0	2	5		5	1	
"	fair	0	3	10				
"	"	1	1	12				
"	"	0	2	5			6	
"	check	1	1	9		3		
"	"	0	2	4		3	4	
"	crack	0	4	3		3	1	2
"	"	0	0	5	3	2		
TOTAL OF EACH FAILURE:		2	23	83	3	17	12	2
AVERAGE OF EACH TYPE OF FAILURE: Nails/Shoe:		.18	2.09	7.55	.27	1.55	1.09	.18

* Some portion of these heels such as a corner or the breast could be moved relative to the outsole by hand.

One shoe with Heels Off -- Thirteen nails lost or broken at midsole-outsole interface.

TABLE VIII

NEW BOOTS, SELECTED FOR MAXIMUM GENERAL WEAR
16 Boots Tested with Tight Heels
6 Boots Tested with Loose Heels

Tightness of Heel	Insole	Known Buckled Nails	Known Clinched Nails	Known Unclinched Nails	Tips Pulled Off	Breaks at M & O Interface	Pulled out of Washers	Pulled Washers
Tight	good	0	6	7				
"	"	0	2	7	4			
"	"	0	5	1	6			
"	"	0	3	3	6			
"	"	0	2	11				
"	"	0	2	9	2			
"	"	0	2	9		1	1	
"	check	0	6	4	3			
"	"	3	2	7		2	2	
"	"	0	0	13				
"	"	0	3	5			4	1
"	crack	0	3	8			2	
"	"	0	5	4			4	
"	"	1	3	6		1	2	1
"	"	0	3	4		3	2	1
"	"	0	4	6		2	1	
TOTAL OF EACH FAILURE:		4	51	104	21	9	18	3
AVERAGE OF EACH TYPE OF FAILURE: Nails/Shoe:		.25	3.19	6.50	1.31	.56	1.13	.19
Loose*	good	0	2	9		2		
"	"	0	2	5		3	3	
"	"	0	3			3	1	
"	crack	0	3	5	4		1	

TABLE VIII (CONT.)

NEW BOOTS, SELECTED FOR MAXIMUM GENERAL WEAR
16 Boots Tested with Tight Heels
6 Boots Tested with Loose Heels

Tightness of Heel	Insole	Known Buckled Nails	Known Clinched Nails	Known Unclinched Nails	Tips Pulled Off	Breaks at M & O Interface	Pulled out of Washers	Pulled Washers
Loose*	crack	0	2	3	2	3	3	
"	"	0		8			5	
TOTAL OF EACH FAILURE:		0	12	30	6	11	13	
AVERAGE OF EACH TYPE OF FAILURE: Nails/Shoe:			2.00	5.00	1.00	1.83	2.17	

* Some portion of these heels such as a corner or the breast could be moved relative to the outsole by hand.

SHOES SHOWING UPPER COMPONENT FAILURES

TABLE IX

62 Boots Tested

Outsole Tread Wear *	Tightness of Heel	Insole	Buckled Nails	Known Clinched Nails	Known Unclinched Nails	Tips Pulled Off	Breakage at M & O Interface	Pulled out of Washers	Pulled Washers
$\frac{1}{2}$	tight	good	0	1	9	2		1	
$\frac{1}{2}$	"	"	0	1	3	9			
$\frac{1}{2}$	"	"		2	5	6		1	
$\frac{1}{2}$	"	"	0	6	6	1			
$\frac{1}{2}$	"	"	0	3	9		1		
$\frac{1}{2}$	"	"	0	6	7				
$\frac{1}{2}$	"	"	0	2	8	3			
$\frac{1}{2}$	"	"	0	1	5	7			
$\frac{1}{2}$	"	"	0	2	4	6	1		
$\frac{1}{2}$	"	"	0	1	9	3			
$\frac{1}{2}$	"	"	0	2	5	5	1		
$\frac{1}{2}$	"	"	1	3	10				
$\frac{1}{2}$	"	"	0	1	4	8			
$\frac{1}{2}$	"	"	0	1	1	8	2	1	
$\frac{1}{2}$	"	"	0	1	9	2	1		
$\frac{1}{2}$	"	"	0	1	6	4	1	1	
$\frac{1}{2}$	"	"	0	2	9	2			
$\frac{1}{2}$	"	"		1	8	4			
$\frac{1}{2}$	"	"	3	3	8	2			
$\frac{1}{2}$	"	"	0	0	5	7			1
$\frac{1}{2}$	"	"	0	0	7	6			
$\frac{1}{2}$	"	"	0	7	6				
$\frac{1}{2}$	"	"	0	7	6				1
$\frac{1}{2}$	"	"	0	1	3	8			
$\frac{1}{2}$	"	"	0	4	7	2			
$\frac{1}{2}$	"	"	0		5	6		2	

SHOES SHOWING UPPER COMPONENT FAILURES

TABLE IX (CONT.)

62 Boots Tested

Outsole Tread Wear*	Tightness of Heel	Insole	Buckled Nails	Known Clinched Nails	Known Unclinched Nails	Tips Pulled Off	Breakage at M & O Interface	Pulled out of Washers	Pulled Washers
½	tight	good	1	1	6	6			
½	"	"			11	2			
½	loose	"			1	5	7		
½	"	"	0	1	2	6	4		
½	"	"			2	4	5	2	
2/3	tight	"	1	4	9	0			
2/3	"	"	0		6	6	1		
2/3	"	"	0	0	8	5			
2/3	"	"	0	0	5		2	6	
2/3	"	"	0	1	6	6			

SHOES SHOWING UPPER COMPONENT FAILURES

TABLE X

Outsole Tread Wear*	Tightness of Heel	Insole	Buckled Nails	Known Clinched Nails	Known Unclinched Nails	Tips Pulled Off	Breakage at M & O Interface	Pulled out of Washers	Pulled Washers
1/3	tight	good	0	1	7	3	2		
1/3	"	"	1	3	2	7	1		
1/3	"	"	0	2	3	6	2		
1/3	"	"	0	3	3	6	1		
1/3	"	"	0	5	5	3			
1/3	"	"	0	5	7		1		
1/3	"	"	0	1	4	8			
1/3	"	"	0	2	11				
1/3	"	"	1	1	7	3	2		
1/3	"	"	0	1	10	2			
1/3	"	"	0	0	10	3			
1/3	"	"	0	1	3	9			
1/3	"	"	0		6	7			
1/3	"	"	0	9	4				
1/3	"	"	0	5	8				
1/3	"	"	0		6	6			1
1/3	"	"	1	1	8	4			
1/3	"	"	1	1	5	7			
1/3	"	"	0	3	7	3			
1/3	"	"	0		4	8		1	
1/3	"	"	0	4	8	1			
1/3	"	"	0	3	8	2			
slight	"	"	0	2	1	10			
"	"	"	0		4	9			
"	"	"		4	7	2			
"	"	"	0	1	9	3			

SHOES SHOWING UPPER COMPONENT FAILURES

TABLE X (CONT.)

	Outsole Tread Wear*	Tightness of Heel	Insole	Buckled Nails	Known Clinched Nails	Known Unclinched Nails	Tips Pulled Off	Breakage at M & O Interface	Pulled out of Washers	Pulled Washers
TOTAL OF EACH FAILURE:				10	124	377	253	35	15	3
AVERAGE OF EACH TYPE OF FAILURE: Nails/Shoe				.16	2.00	6.08	4.08	.56	.24	.05

* The values indicate the amount of the tread worn off the outsole and are given as an indication of the amount the shoe was worn.

FOOTWEAR WITH NO FAILURES

TABLE XI

55 Boots Tested

Outsole Tread Wear*	Tightness of Heel	Insole	Buckled Nails	Known Clinched Nails	Known Unclinched Nails	Tips Pulled Off	Breakage at M & O Interface	Pulled out of Washers	Pulled Washers
none	tight	good	2	4	8	1			
"	"	"	0	2	4	6			
1/4	"	"	0	7	5	1			
"	"	"	0	4	3	6			
"	"	"	0	0	8	5			
"	"	"	0	4	2	7			
"	"	"	1	6	6	1			
"	"	"	1	3	10				
"	"	"	0	3	2	9			
"	"	"	0	0	10		2		
"	"	"	0	8	13	2		1	
"	"	"	0	2	4	1			
"	"	"	0	0	2	0			
"	"	"	0	6	6	3			
1/3	"	"	0	0	4	11			
"	"	fair	0	0	9	7			
"	"	good	1	3	8	6			
"	"	"	0	2	5	2			
"	"	"	0	2	5	3			
"	"	"	1	1	1	7			
"	loose	"	0	0	2	4	4		
"	tight	"	0	11	3			1	
"	"	"	0	5	9	6			
"	"	"	0	4	7	6			
"	"	"	0	2	1	2			
"	"	"	0	3	7	3			
"	"	"	0	2	6	10			

FOOTWEAR WITH NO FAILURES

TABLE XI (CONT.)

55 Boots Tested

Outsole Tread Wear*	Tightness of Heel	Insole	Buckled Nails	Known Clinched Nails	Known Unclinched Nails	Tips Pulled Off	Breakage at M & O Interface	Pulled out of Washers	Pulled Washers
1/3	tight	good	0	3	2	1	1		
"	"	"	1	2	8	6	1		
"	"	"	0	4	6	8			1
$\frac{1}{2}$	"	"	0	0	11	2			
"	"	"	0	3	2	3			
"	"	"	0	2	2				
"	"	"	1	4	7	11			
"	"	"	0	2	3	8			
"	"	"		0		2			
"	"	"				5		1	
1/2	tight	good	0	1		12			
"	loose	"	0	2	4	4	3		
"	tight	"	0	5	7	1			
"	"	"	0	9	2	2			
"	"	"	0	8	2	3			
2/3	"	"	0	1	4	8			
"	"	"	0	4	8	1			
"	"	"	0	3	7	3			
"	"	"	1	0	13	0			
"	"	"	0	0	10	3			
"	"	"	1	12					
"	"	"	0	1	5	7			
all off	"	"	0	2	2	9			
"	"	"	0	3	4	5	1		
"	"	"	0	1	6	6			
"	"	"	0	3	8	2			

FOOTWEAR WITH NO FAILURES

TABLE XI (CONT.)

55 Boots Tested

Outsole* Tread Wear	Tightness of Heel	Insole	Buckled Nails	Known Clinched Nails	Known Unclinched Nails	Tips Pulled Off	Breakage at M & O Interface	Pulled out of Washers	Pulled Washers
all off	tight	good	1	7	4	2			
"	"	"	0	0	9	2	2		
TOTAL OF EACH FAILURE:			12	172	299	225	14	3	1
AVERAGE OF EACH TYPE OF FAILURE: Nails/Shoe:			.22	3.13	5.44	4.09	.25	.05	.02

* The values indicate the amount of the tread worn off the outsole and are given as an indication of the amount the shoe was worn.

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